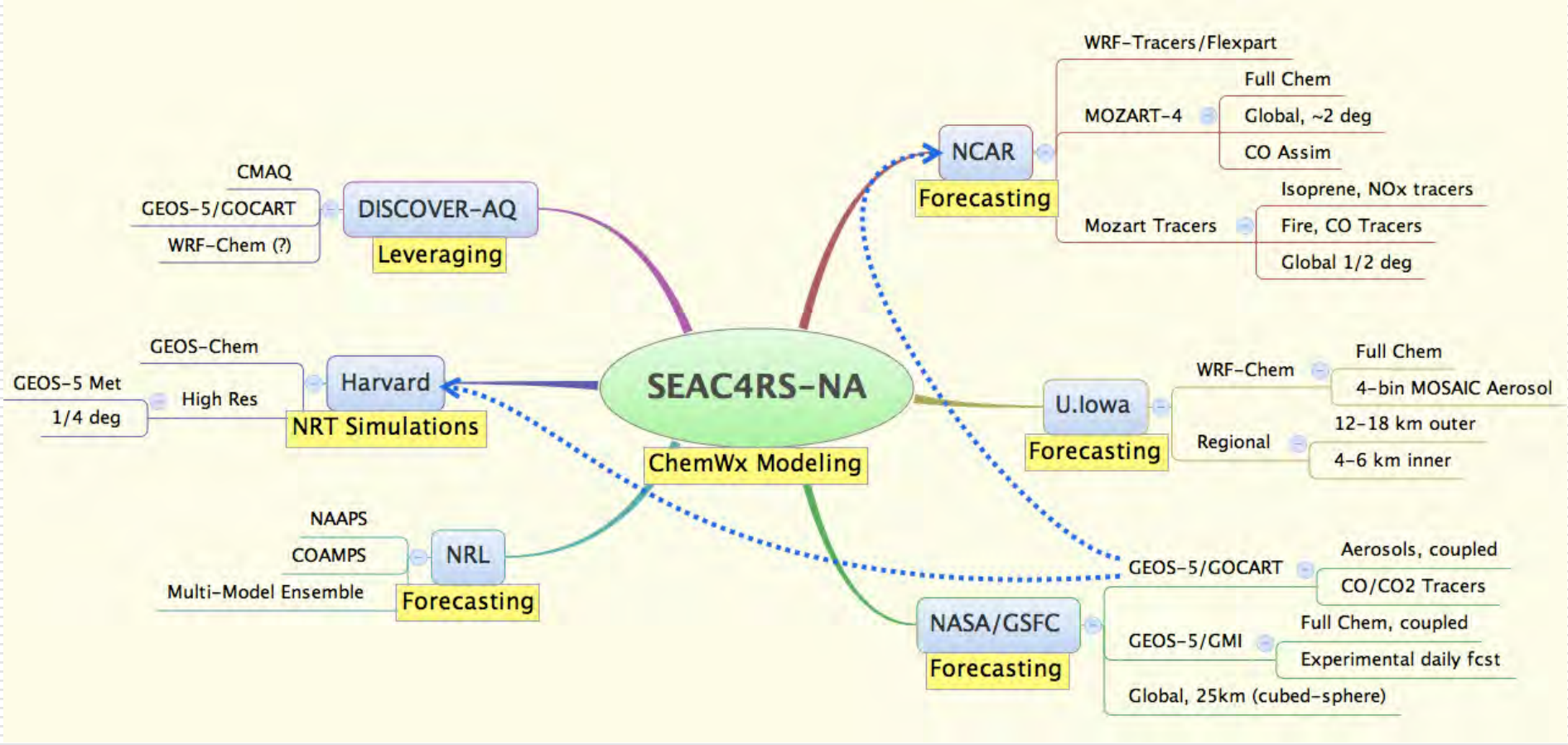
Modeling Capabilities during SEAC^{4}RS-NA:
Forecasting Support and in-Field Data Analysis

Arlindo da Silva[(1)] , Louisa Emmons[(2)], Pablo Saide[(3)]

(1) Global Modeling and Assimilation Office, NASA/GSFC
(2) NCAR
(3) University of Iowa

SEAC4RS Science Team Meeting
April 29-May 1 2013

SEAC4RS-NA Modeling Capabilities at a Glance



NCAR Modeling Support for SEAC4RS

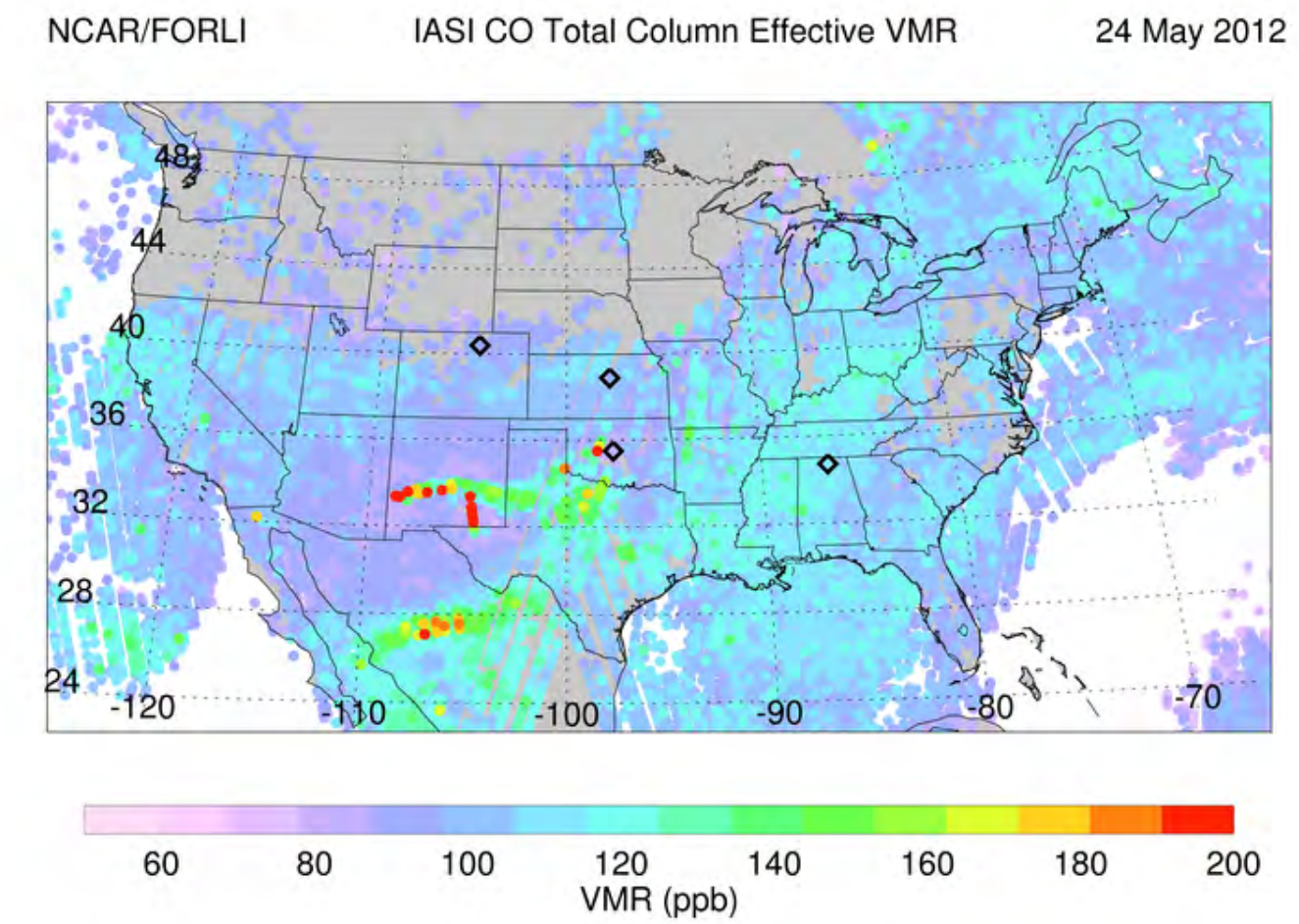
Louisa Emmons

Mary Barth, Gabriele Pfister, Helen Worden,
Mijeong Park, Christoph Knote, Christine Wiedinmyer

Atmospheric Chemistry Division, NCAR

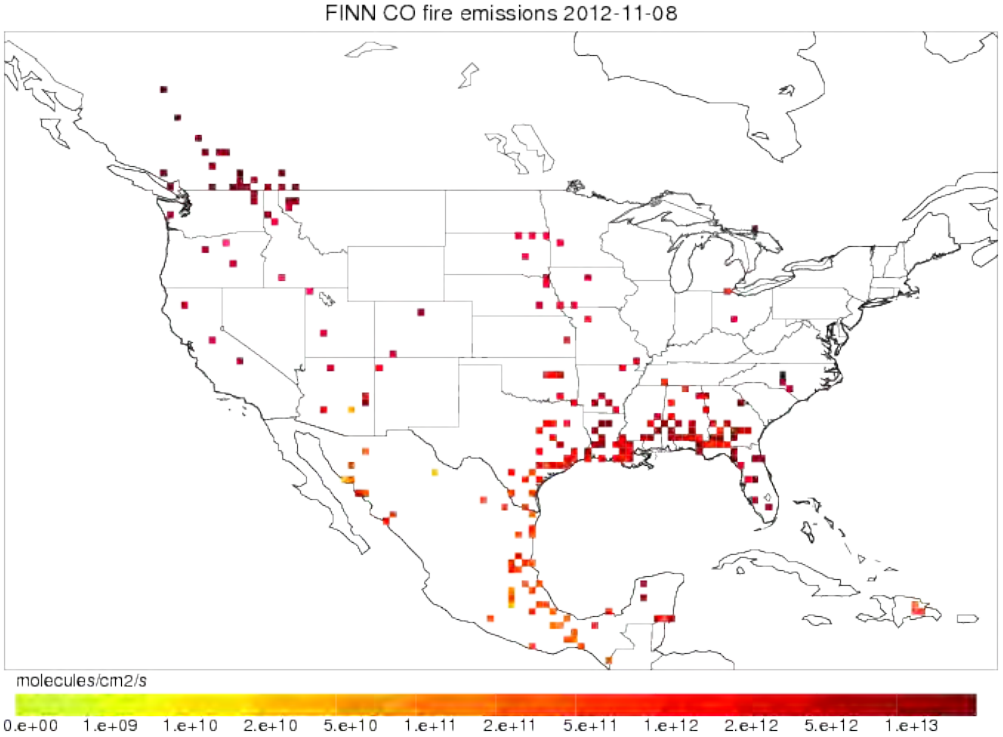
Carbon Monoxide Satellite Observations

- MOPITT CO – available within a day of overpass
- IASI CO – about 2-day delay, global coverage 2x/day
- Plots will be available at: http://www.acd.ucar.edu/acresp/

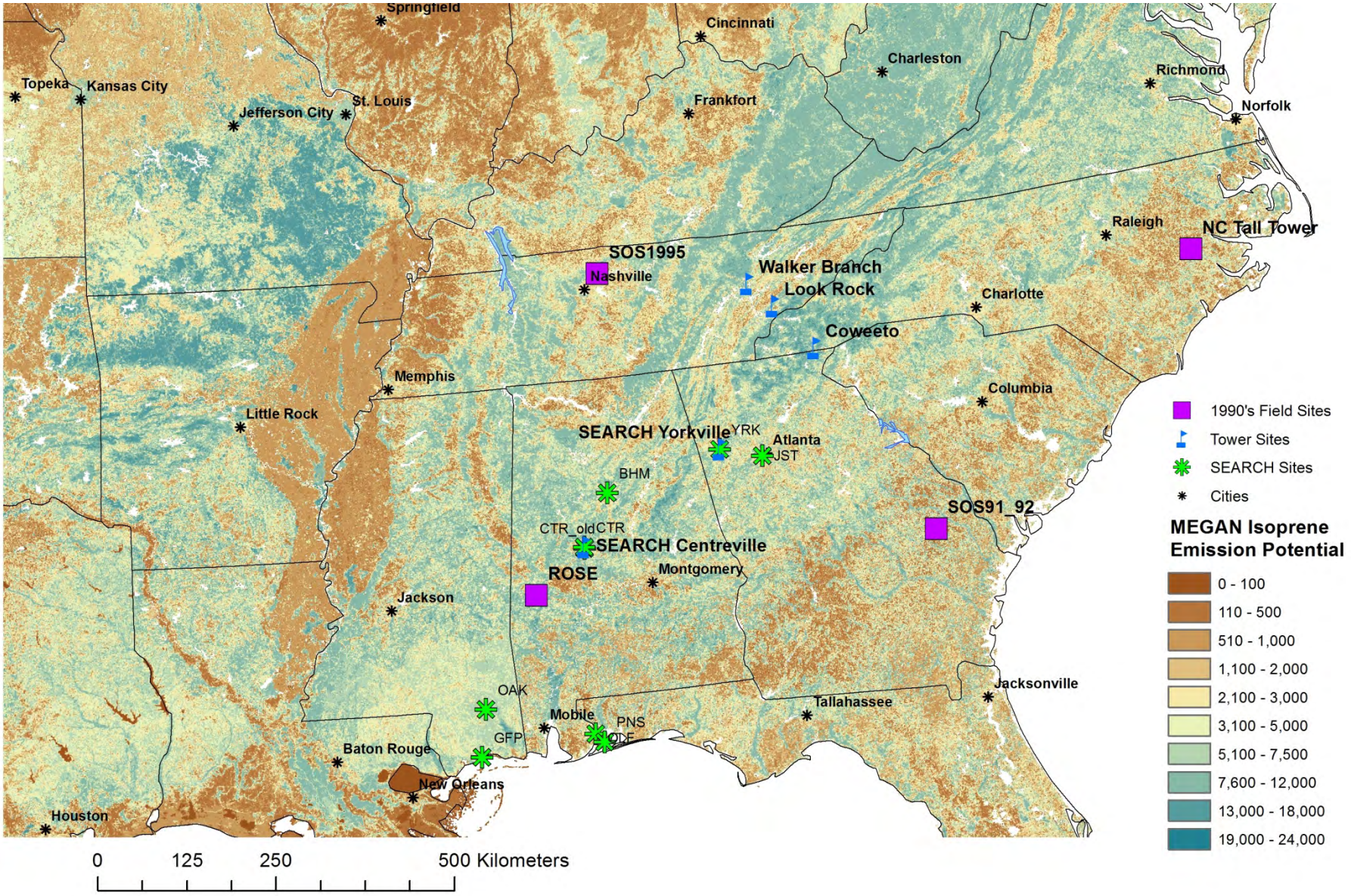


Fire Emissions:
Fire INventory from NCAR (FINN)

- Daily fire emissions of trace gases and particles are produced
- FINN is run in real-time based on MODIS Rapid Response fire counts [*Wiedinmyer, GMD, 2011*]
  http://www.acd.ucar.edu/acresp/forecast/fire-emissions.shtml
- Plots and data files available each day



MEGAN: biogenic emissions model –
online in MOZART, CAM-chem/CLM, WRF-chem
real-time emissions can be made available



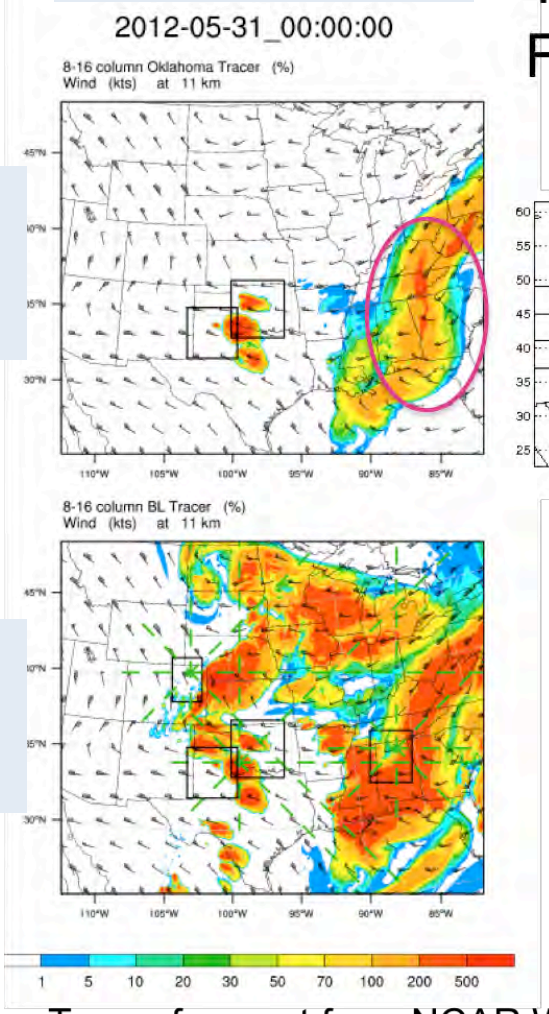
WRF-Tracers and Flexpart – Example from DC3

for SEAC4RS, simulations will be chosen to address science questions

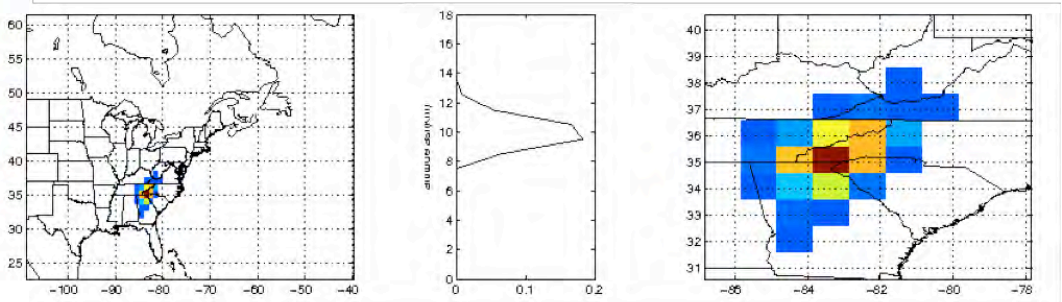
WRF (Δx=3km) with PBL tracers

PBL tracer from Oklahoma/West Texas at 11 km

PBL tracer from entire domain in UT



Tracers & Flexpart Trajectory Forecast



Tracer forecast from Flexpart initialized at ~01 UTC 05-30 at the latitudes, longitudes, and altitudes of the GV anvil passes. Results are valid for 18 UTC 05-30.

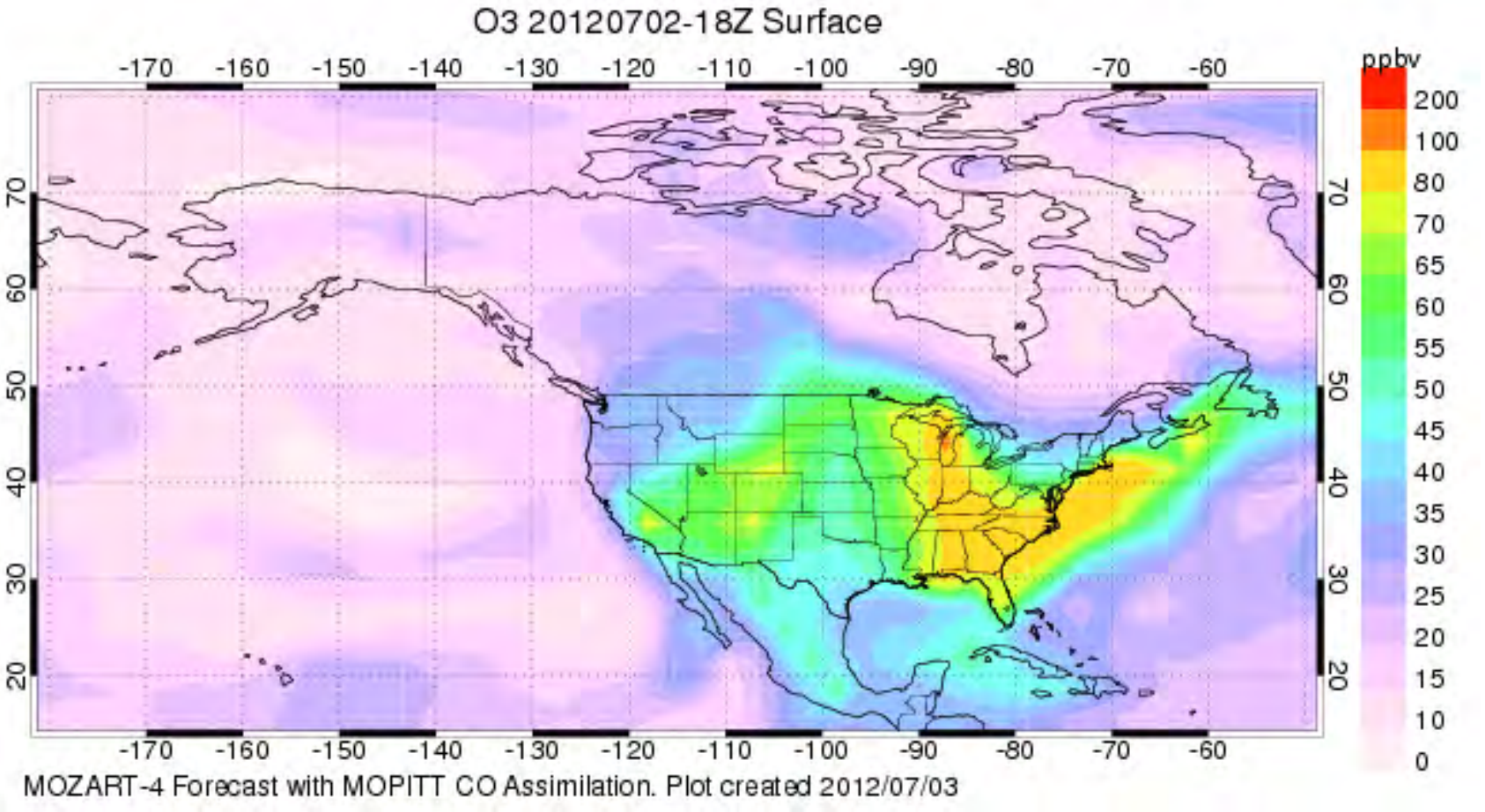
Tracer forecast from NCAR WRF initialized at 12UTC 05-29

MOZART-4 driven by GEOS-5 with assimilation of MOPITT CO

Full chemistry at 1.9°x2.5°

http://www.acd.ucar.edu/acresp/forecast/

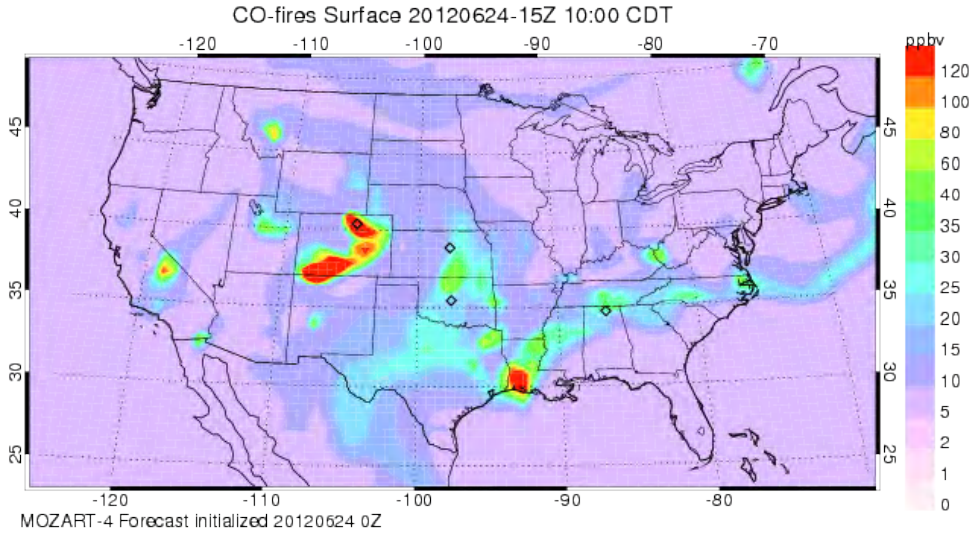
5-day forecasts, hourly output, currently operational

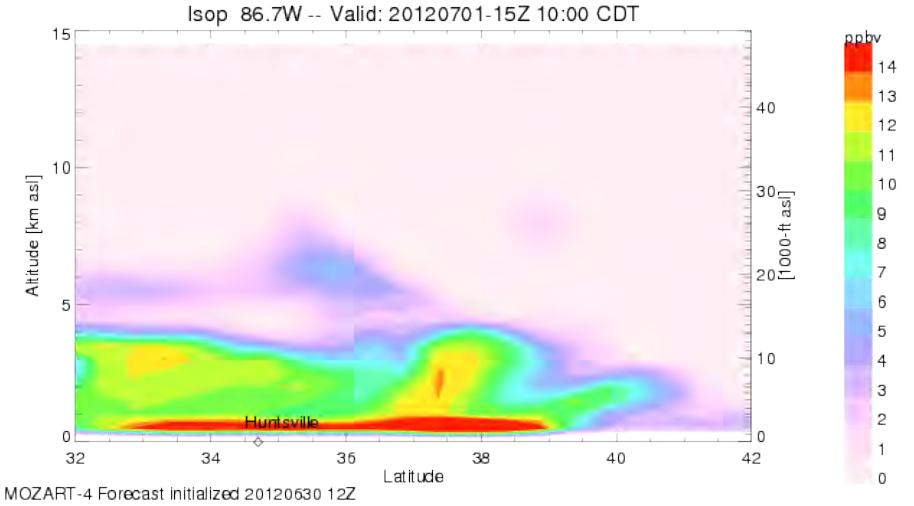


MOZART-4 Tracers

Global forecasts of artificial tracers at 0.5°x0.6°

- Isoprene-like tracer based on MEGAN isoprene emissions
- Anthropogenic NOx tracer
- Fire & anthro CO tracers for various regions
- Others can be added as needed
  (based on various sources, lifetimes, soluble/insoluble)
- Similar to forecasts for DC3 (http://www.acd.ucar.edu/acresp/dc3/)





Post-Campaign Analysis

CAM-chem and WRF-chem will be run after the campaign and provided to the Science Team for analysis of the observations

- FINN fire emissions will be updated with final MODIS thermal anomalies and regional burn information and used in the model simulations
- CAM-chem (MOZART-4 chemistry) will be driven by GEOS-5 (or MERRA) meteorology
- WRF-chem will be run with MOZART-4 chemistry and aerosols (MAM & SOA)
- Model results will be interpolated to the flight tracks and submitted to the data archive
- Science Team may request other (custom) products

UIOWA Forecasting Capabilities

Pablo Saide, Greg Carmichael, Scott Spak

SEAC4RS science meeting

April 29th, 2013

UIOWA Forecasting Capabilities

- WRF-Chem full chemistry+4 bin MOSAIC aerosol and WRF-tracer for emission regions/sectors
  - 12 or 18km resolution, with a inner moving nest of 4 or 6km
  - 3 day forecasts, NAM or GFS meteorology
  - MOZART or MACC (ECMWF) chemical boundary conditions
  - FINN or QFED fire emissions, MEGAN biogenics, GOCART dust
  - NEI or D. Streets SEAC4RS anthropogenic emissions
  - Radiative feedback on, aerosol activation off (but aerosol number concentration used as proxy)
- AOD assimilation using NASA NNR or NRL-UND products
- Post processing through NCL and/or UPP
- Output on UIOWA webpage and possibly on NASA through OpenDap server
- All flexible depending on this meeting decisions

UIOWA WEBPAGE

BACK GO TO CROSS-SECTION

SEAC4RS 18km Full Chemistry and Tracer Forecast, 00h = 06UTC, 26/06/2012

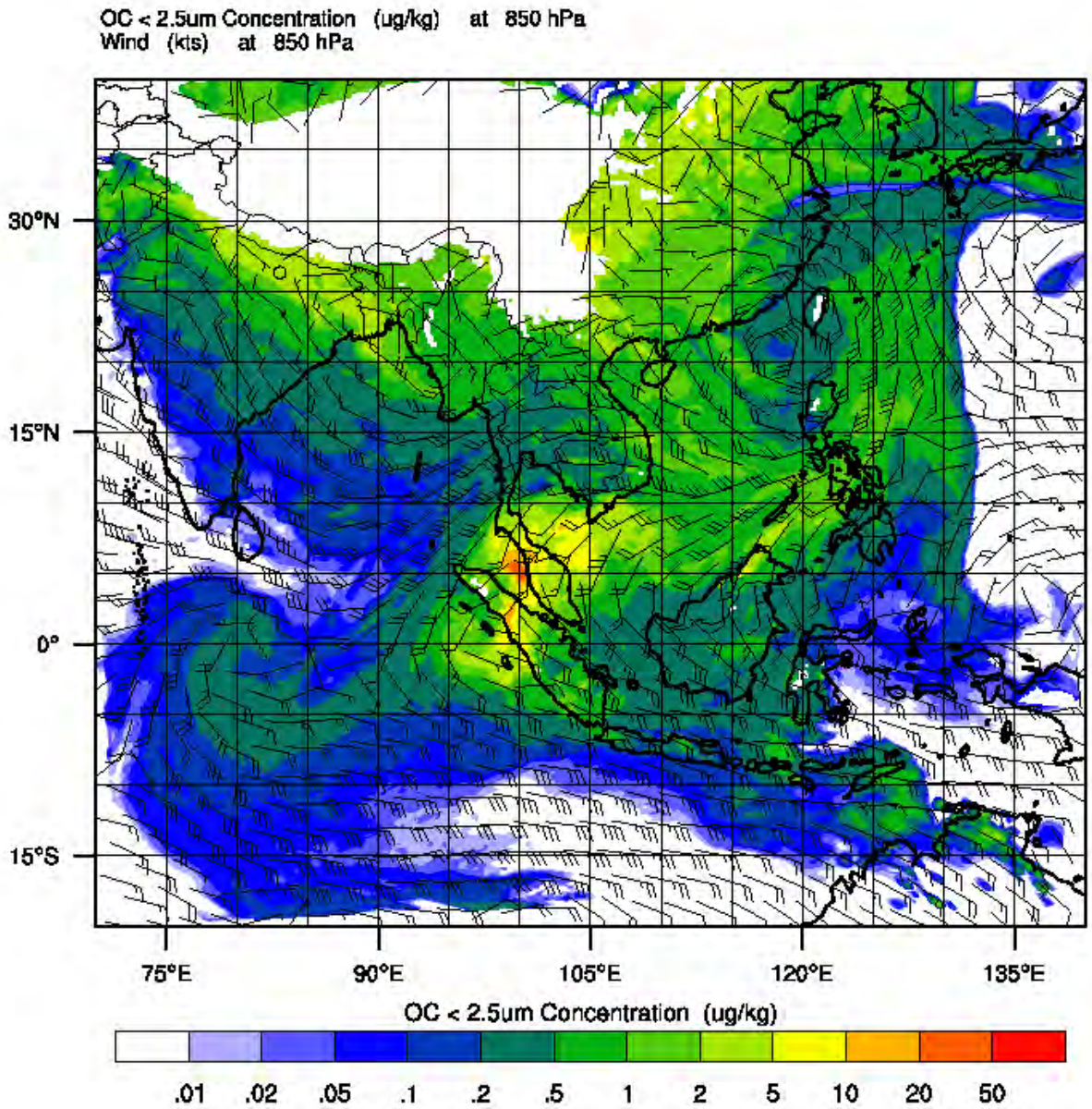
Please select pressure 850 mb, START 6 and END time step - 72 + to see

Full Chemistry: AOD TOT | BC | CO | ISOP | ISOP+PRODS | NO3 | NUM | O3 | OC | DUST COARSE | DUST FINE | PM2.5 | SeaSalt COARSE | SeaSalt FINE | SO2 | SO4

Tracers: CO BB | CO THAI | CO CHINA | CO INDIA | CO VIETNAM | CO NEPAL | CO INDONESIA | CO SHIPPING | SO2 VOLCANO

Meteorology: CAPE | CLD BASE | CLD Incidence | CLD TOP | IWP | LWP | LWP+IWP | QV | PBL Height | POT VORT | PRECIP CONV | PRECIP TOT | RH | T | TROP HEIGHT | TROP T | W

Init: 2012-06-26_06:00:00
Valid: 2012-06-29_06:00:00



UIOWA WEBPAGE

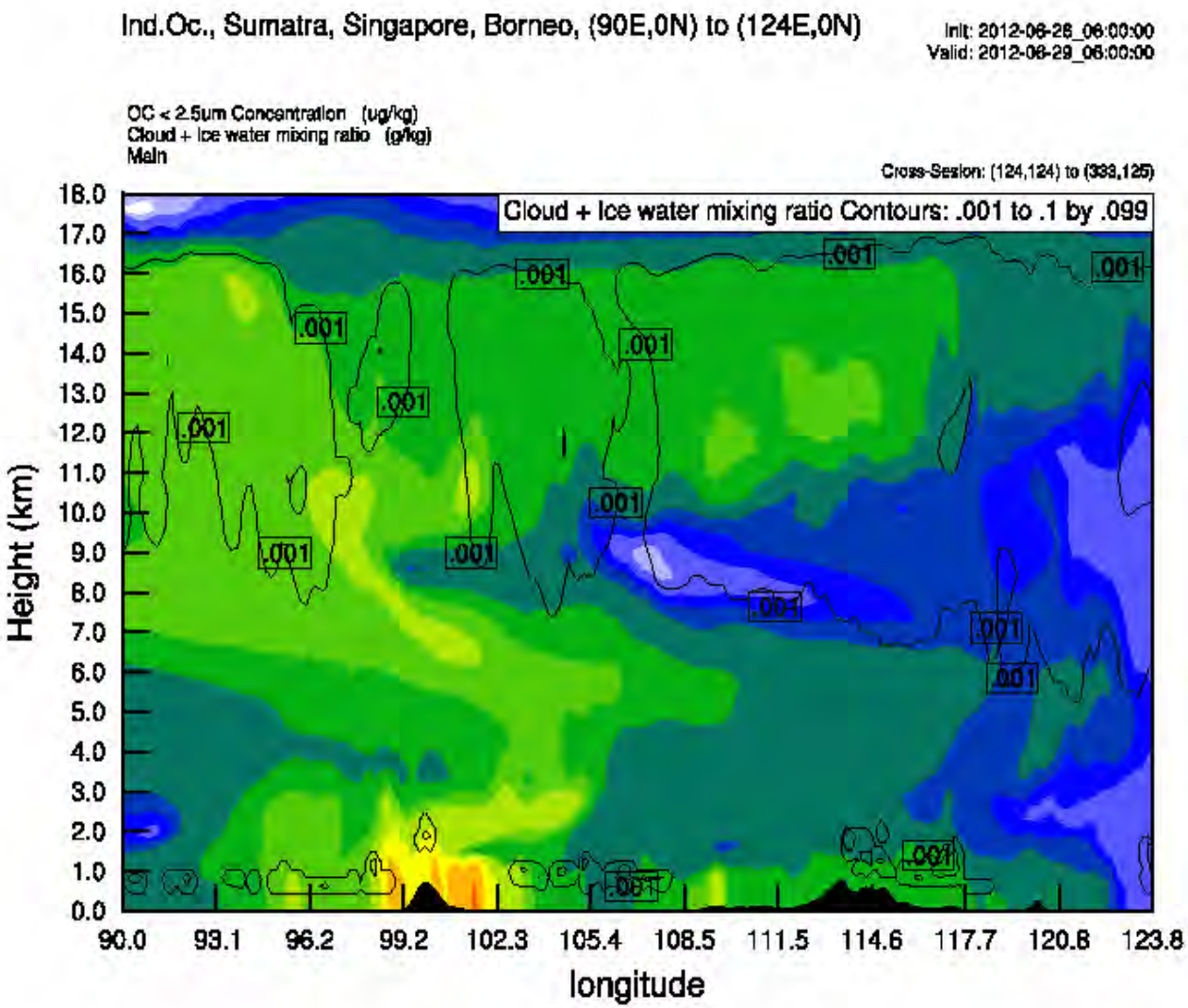
BACK GO TO MAPS

SEAC4RS 18km Full Chemistry and Tracer Forecast, 00h = 06UTC, 26/06/2012

Please select Cross-section # 4, START 6 and END time step - 72 + to see

Full Chemistry: AOD TOT | BC | CO | ISOP | ISOP+PRODS | NO3 | NUM | O3 | OC | DUST COARSE | DUST FINE | PM2.5 | SeaSalt COARSE | SeaSalt FINE | SO2 | SO4

Tracers: CO BB | CO THAI | CO CHINA | CO INDIA | CO VIETNAM | CO NEPAL | CO INDONESIA | CO SHIPPING | SO2 VOLCANO



GEOS-5 Forecasting Support for SEAC^{4}RS-NA

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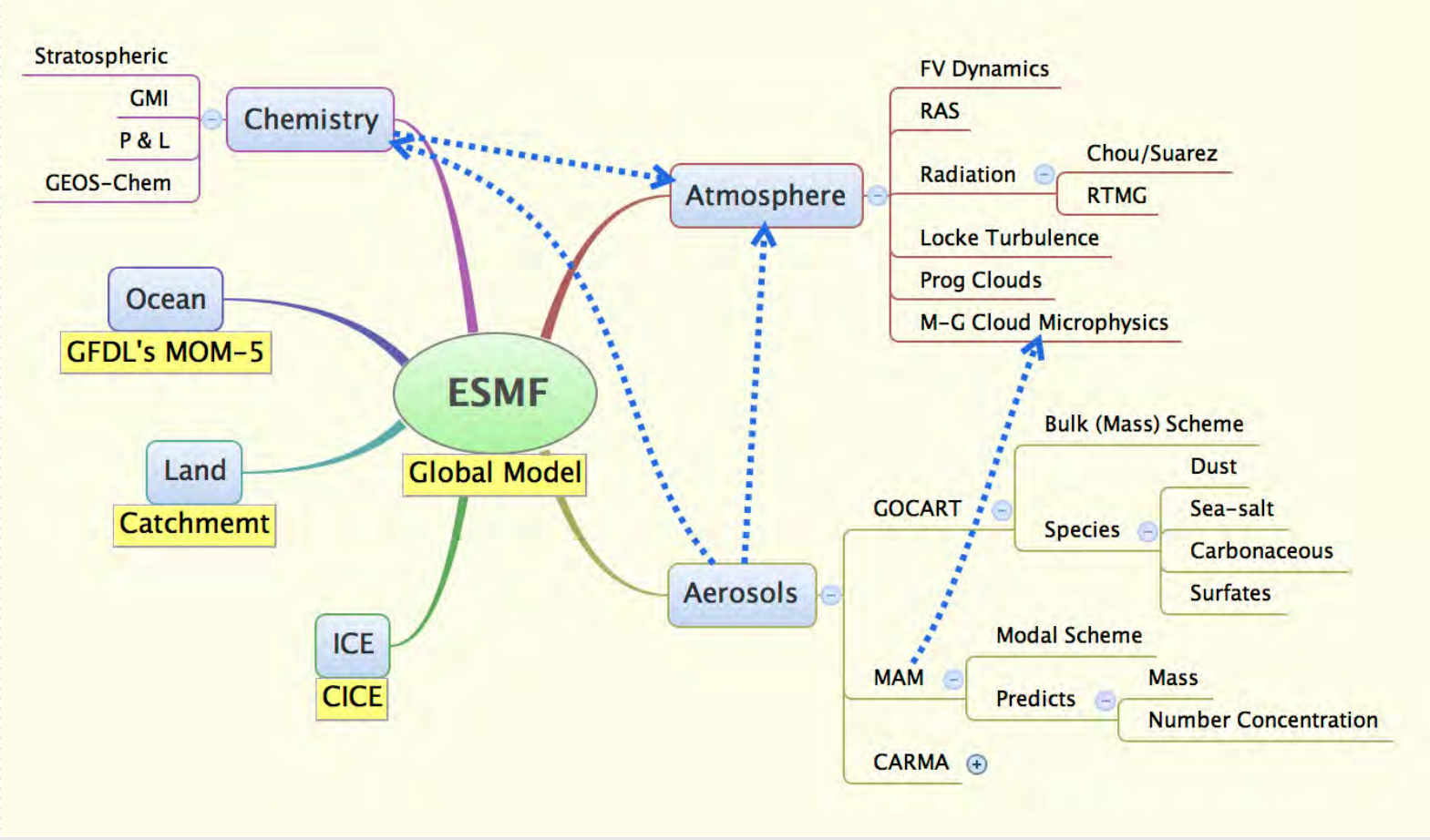
(2) Atmospheric Chemistry and Dynamics Branch, NASA/GSFC

(3) Morgan State University/GESTAR

(4)ORAU

(5) SSAI

GEOS-5 Earth-System Model

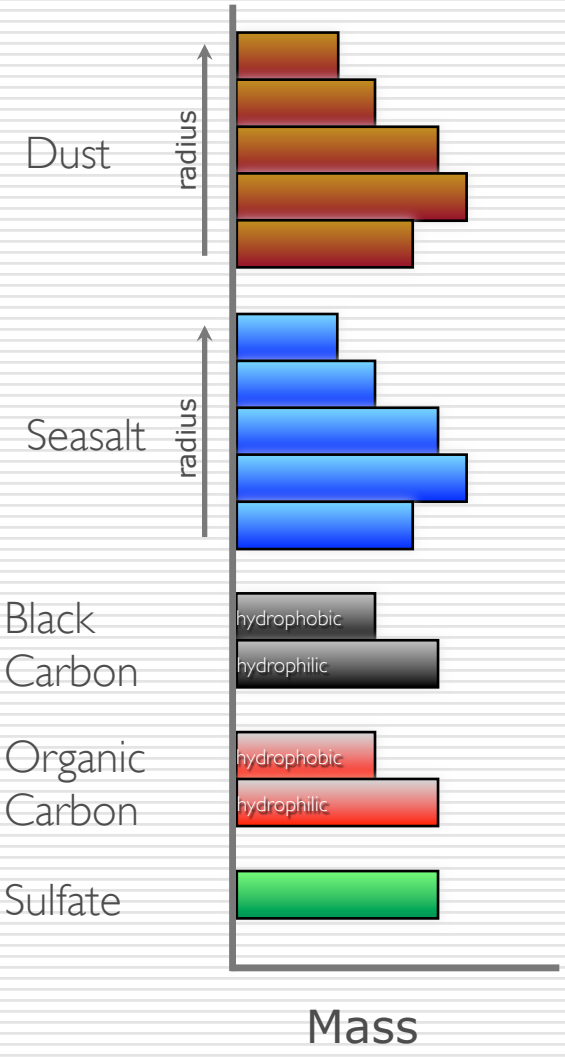


From weather to seasonal to decadal time scales

GEOS-5 Atmospheric Data Assimilation System

Feature	Description
Model	GEOS-5 Earth Modeling System, with GOCART coupled to radiation parameterization
Fire Emissions	QFED: Daily, NRT, MODIS FRP based
Met Data Assim	Full NWP observing system (uses GSI)
Aerosol Data Assimilation	Local Displacement Ensembles (LDE) MODIS reflectances (Aqua & Terra) AERONET Calibrated AOD's (Neural Net) Stringent cloud screening
Forecasts	5 day forecasts twice daily: 0Z an 12Z
Resolution	25 km (cubed-sphere), 72 layers, top ~85 km
Aerosol Species	Dust, sea-salt, sulfates, organic & black carbon
Carbon Species	CO_2, CO with several tagged tracers

GOCART Component



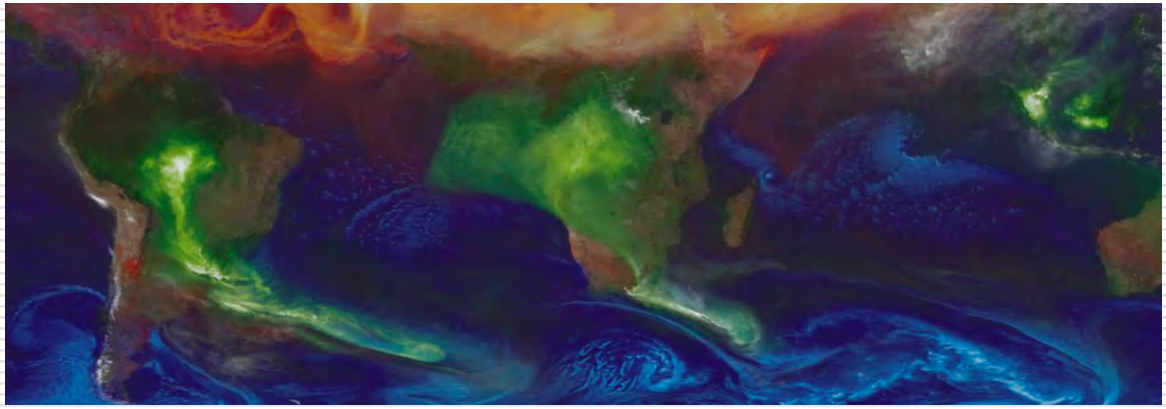
- Goddard Chemistry, Aerosol, Radiation, and Transport Model [Chin et al. 2002]
- Sources and sinks for 5 non-interactive species

dust	wind and topographic source, 5 mass bins
sea salt	wind driven source, 5 mass bins
black carbon	anthropogenic and wildfire source, mass hydrophic and hydrophilic
organic carbon	anthropogenic, biogenic, and wildfire source, mass hydrophic and hydrophilic
sulfate	anthropogenic and wildfire source of SO2, oxidation to SO4 mass

- Convective and large scale wet removal
- Dry deposition (and sedimentation for dust and sea salt)
- Optics based primarily on OPAC

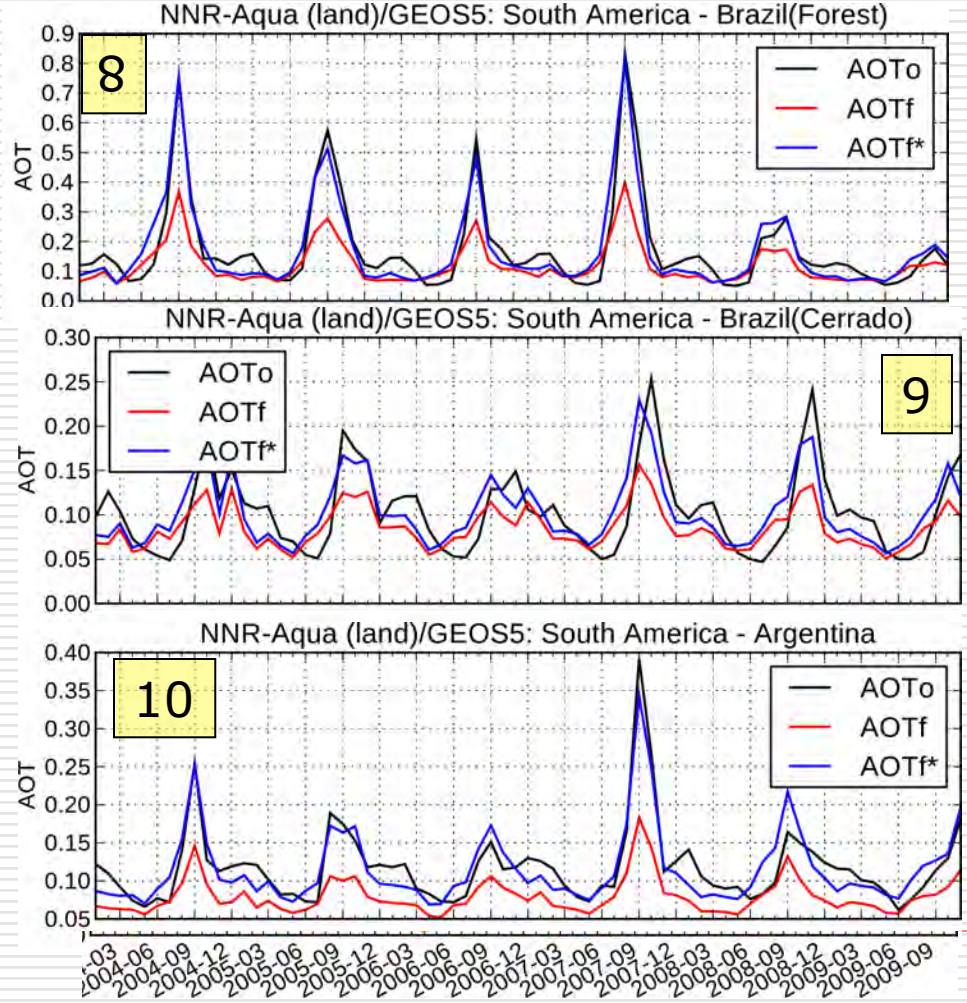
QFED: Quick Fire Emission Dataset

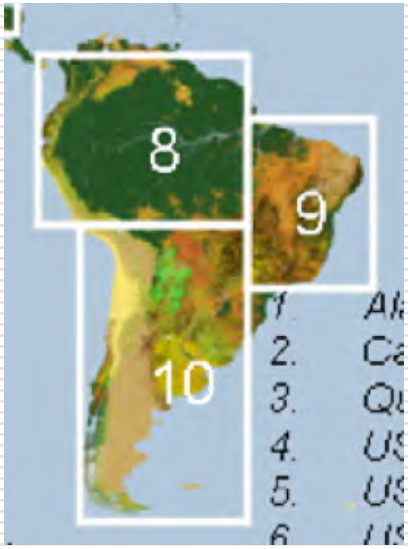
- Top-down algorithm based on MODIS Fire Radiative Power (AQUA/TERRA)
- FRP Emission factors tuned by means of inverse calculation based on MODIS AOD data.
- Daily mean emissions, NRT (thanks to LANCE)
- Prescribed diurnal cycle



JCSDA: inclusion of geo-stationary information

QFED Calibrated by MODIS AOD





GEOS-5 Aerosol Optical Depth

___ QFED (GFED Calibrated)

___ QFED (MODIS Calibrated)

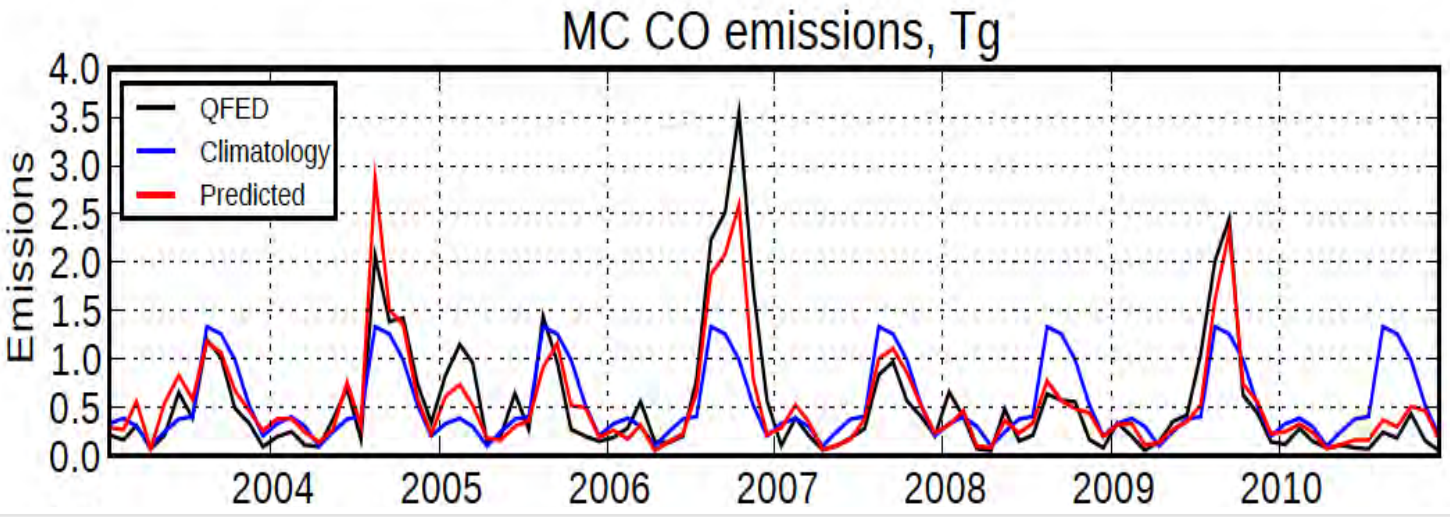
___ MODIS Retrievals

Modeling Interannual Variability of Biomass Burning Emissions

- BB emission anomalies respond directly to precipitation and surface humidity conditions
- The normalized Canadian Fire Weather Index captures the *fammability* conditions as a function of surface meteorology

- Parameterization:

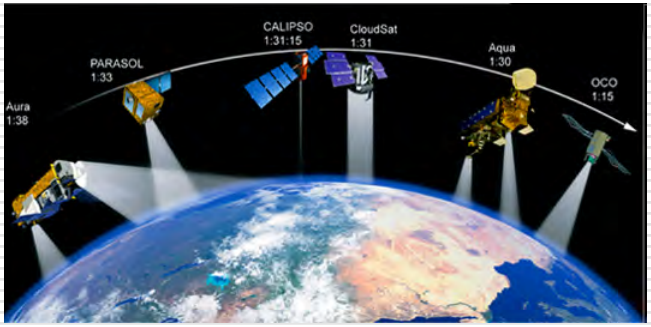
$$E = \varepsilon \left(\frac{I}{I_{clm}} \right)^{\alpha_b} E_{clm}$$



Maritime Continent Example

Aerosol Data Assimilation

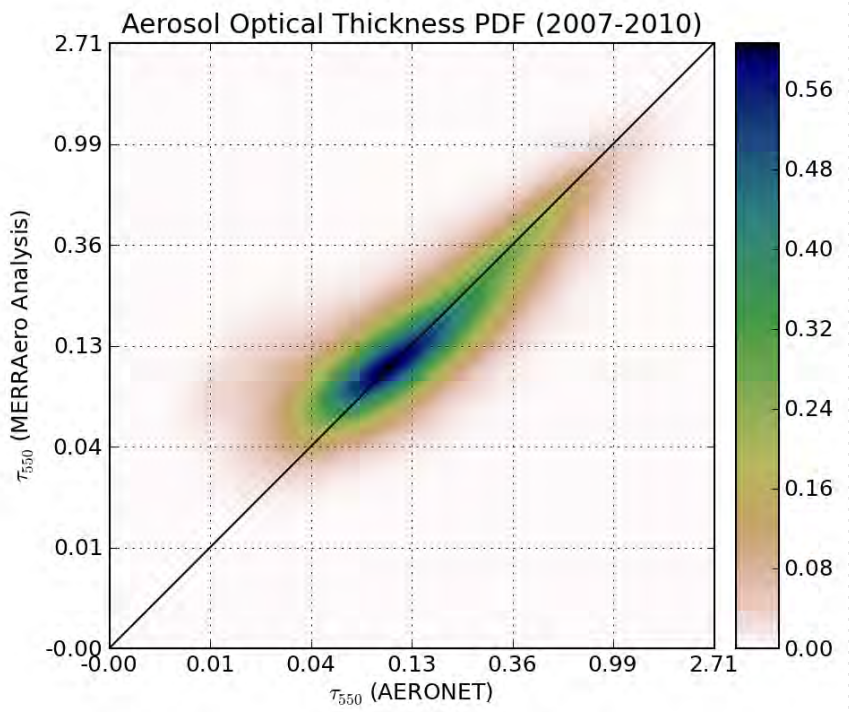
- Focus on NASA EOS instruments, MODIS for now

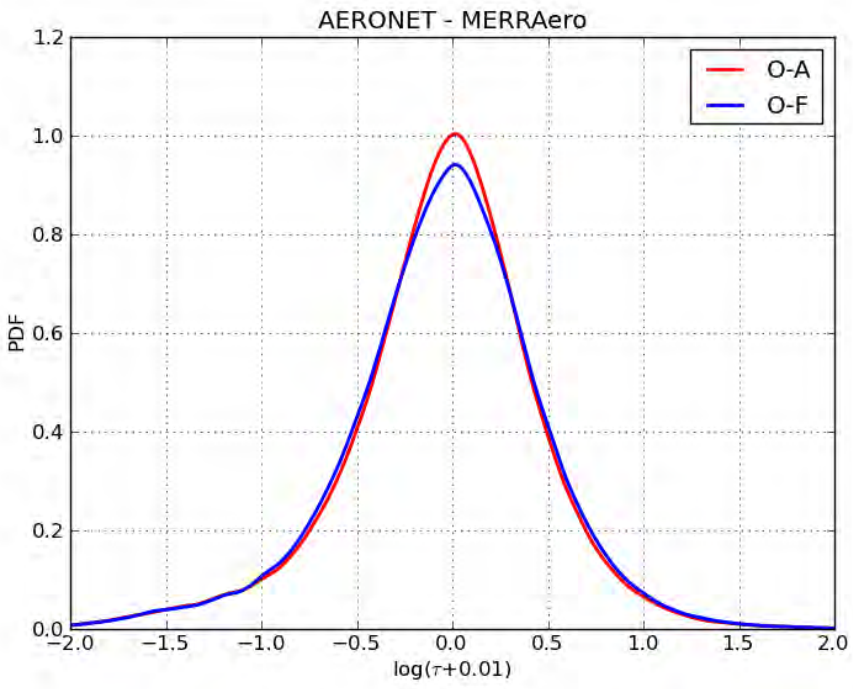


- Global, high resolution (1/4 deg) AOD analysis
- 3D increments by means of Lagrangian Displacement Ensembles (LDE)
- Neural-Net AOD Retrievals

- Simultaneous estimates of background bias (*Dee and da Silva 1998*)
- Adaptive Statistical Quality Control (*Dee et al. 1999*):
  - State dependent (adapts to the error of the day)
  - Background and Buddy checks based on log-transformed AOD *innovation*
- Error covariance models (*Dee and da Silva 1999*):
  - Innovation based
  - Maximum likelihood

AERONET Validation of Aerosol Assimilation

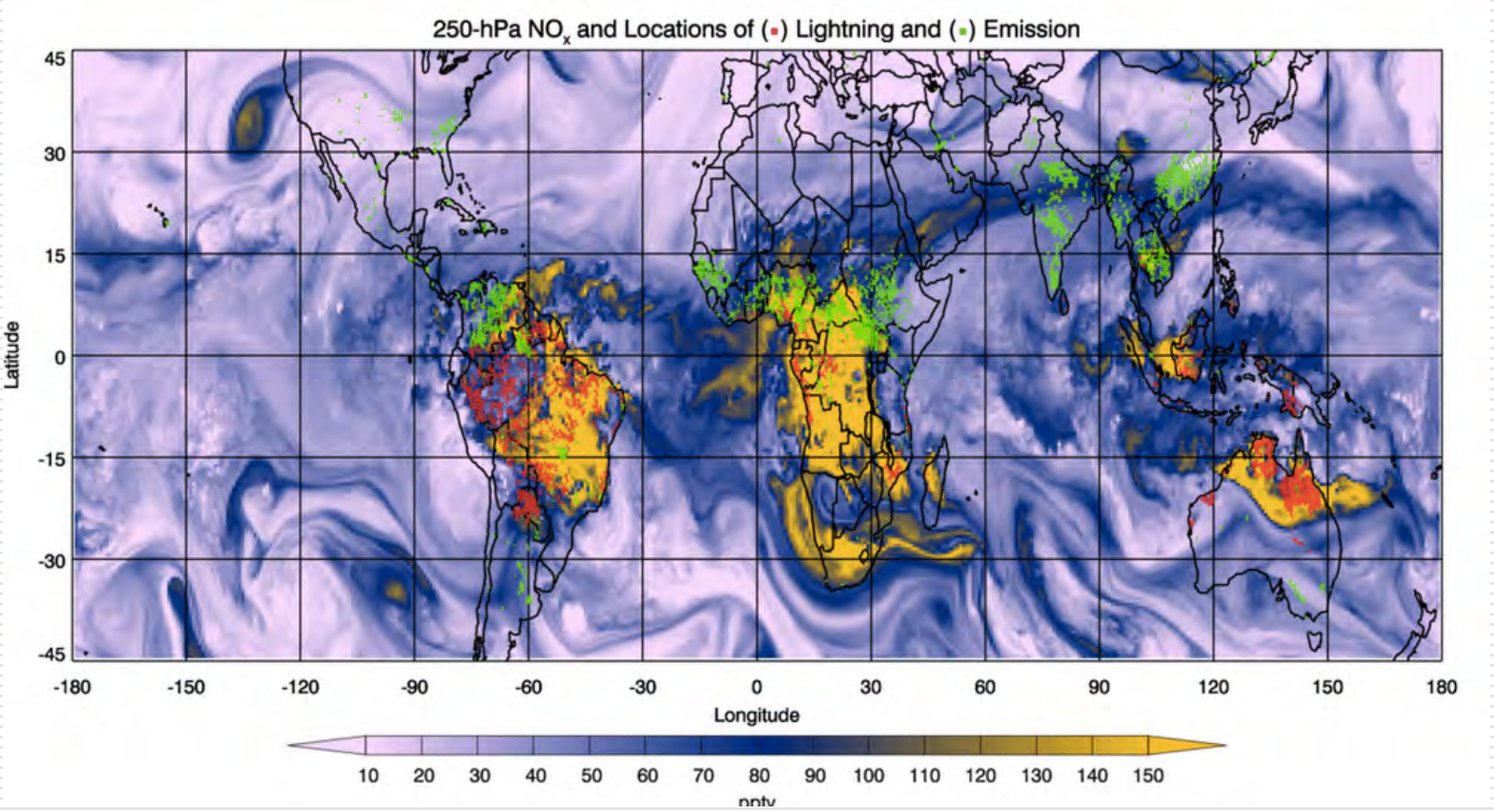




$$\eta = \log(\tau + 0.01)$$

Based on 2007-10 data, aerosol assimilated fields.

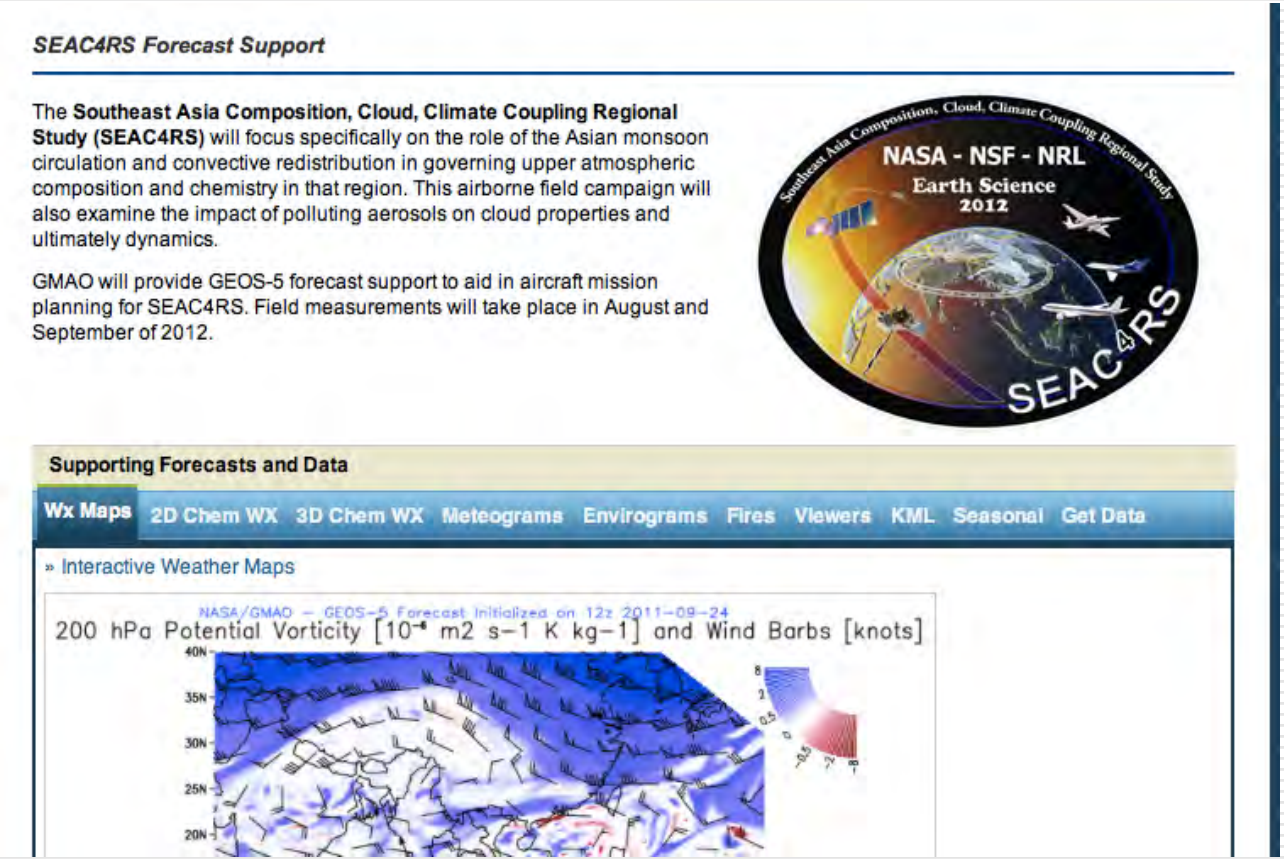
A possibility: Experimental Global 25 km GEOS-5/GMI Forecasts



(once a day, 3 or 5 day forecasts)

Courtesy: S. Pawson, E. Nielsen

Mission Specific Customization: SEAC4RS-Asia



http://gmao.gsfc.nasa.gov/projects/SEAC4RS/

GEOS-5 Support for HS3 ..

Hurricane and Severe Storm Sentinel (HS3)
Forecast Support

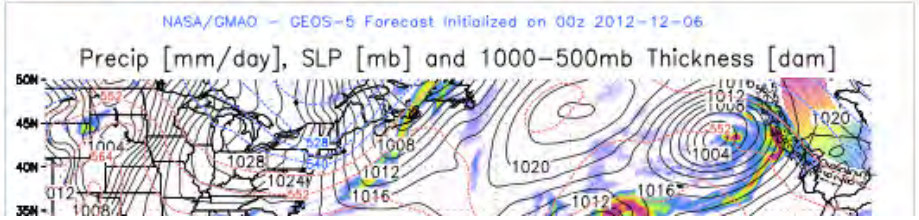
The Hurricane and Severe Storm Sentinel (HS3) is a five-year mission specifically targeted to investigate the processes that underlie hurricane formation and intensity change in the Atlantic Ocean basin. HS3 is motivated by hypotheses related to the relative roles of the large-scale environment and storm-scale internal processes.

Field measurements will take place for one month each during the hurricane seasons of 2012-2014. Test flights will begin in August 2011.

Supporting Forecasts and Data

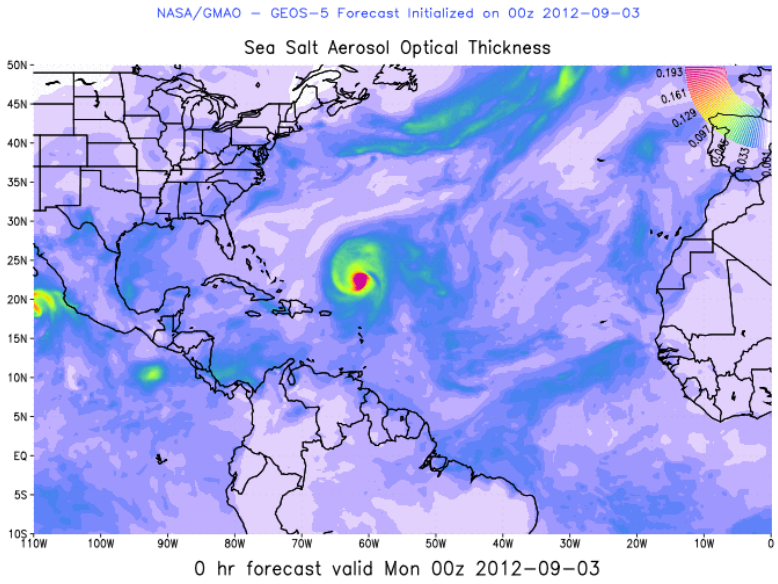
Wx Maps | 2D Chem WX | 3D Chem WX | Meteograms | Aerograms | Viewers | KML | Get Data

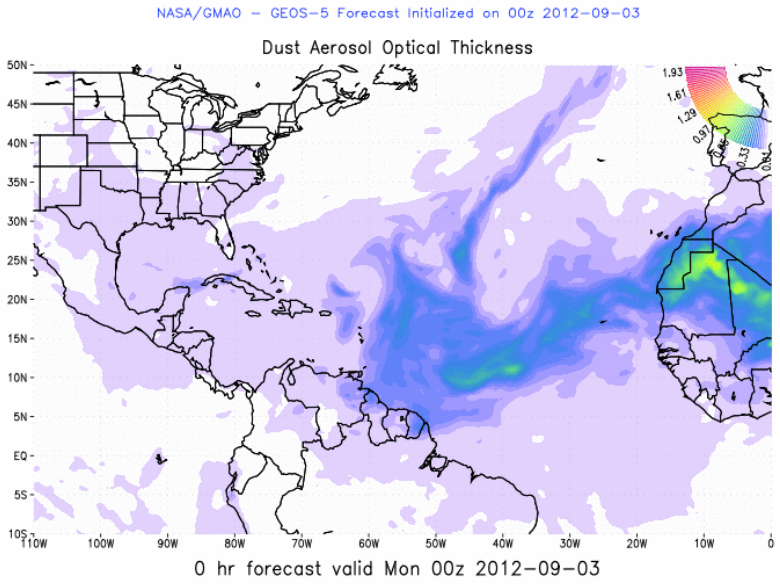
» Interactive Weather Maps

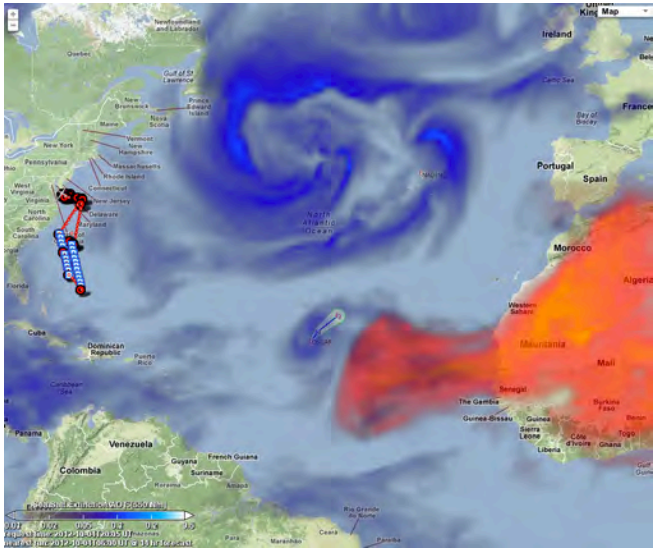


http://gmao.gsfc.nasa.gov/projects/HS3/

HS3 Deployment Support





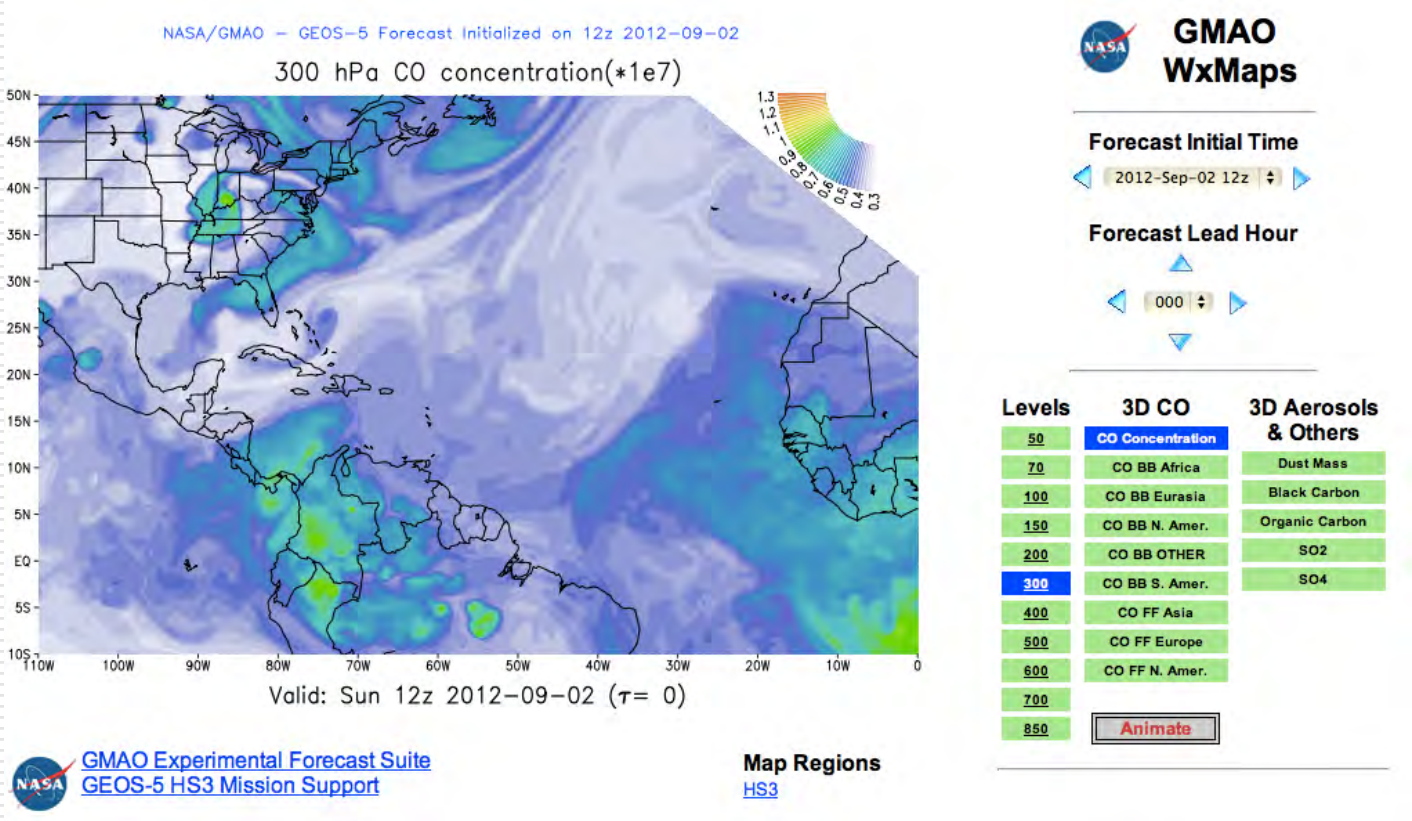


Deployment Activities

4 x day, 5-day meteorological and aerosol forecasts with products made available by web pages, web map service, opendap, etc.

Pete Colarco and Ed Nowottnick were deployed during parts of the campaign to help forecasting and flight planning activities

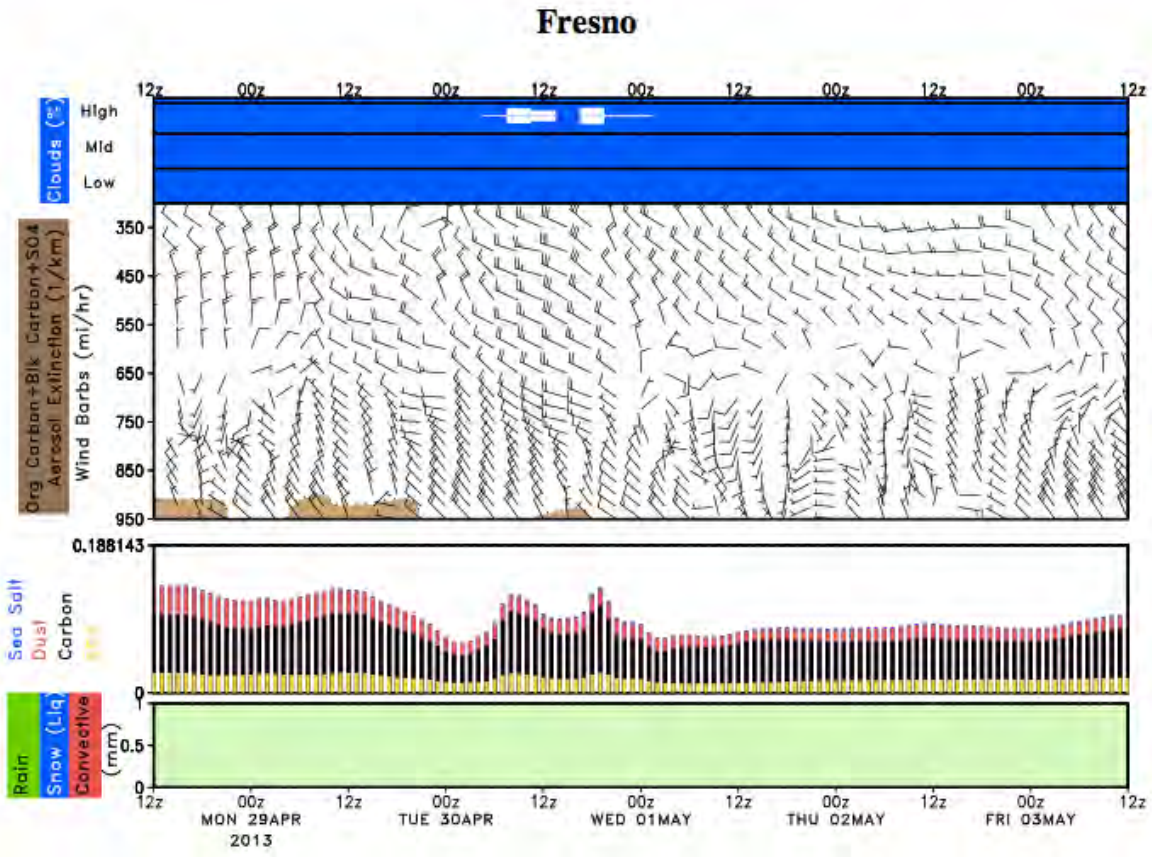
HS3 Customized Maps



DISCOVER-AQ

http://gmao.gsfc.nasa.gov/projects/DISCOVER-AQ/

Aerograms

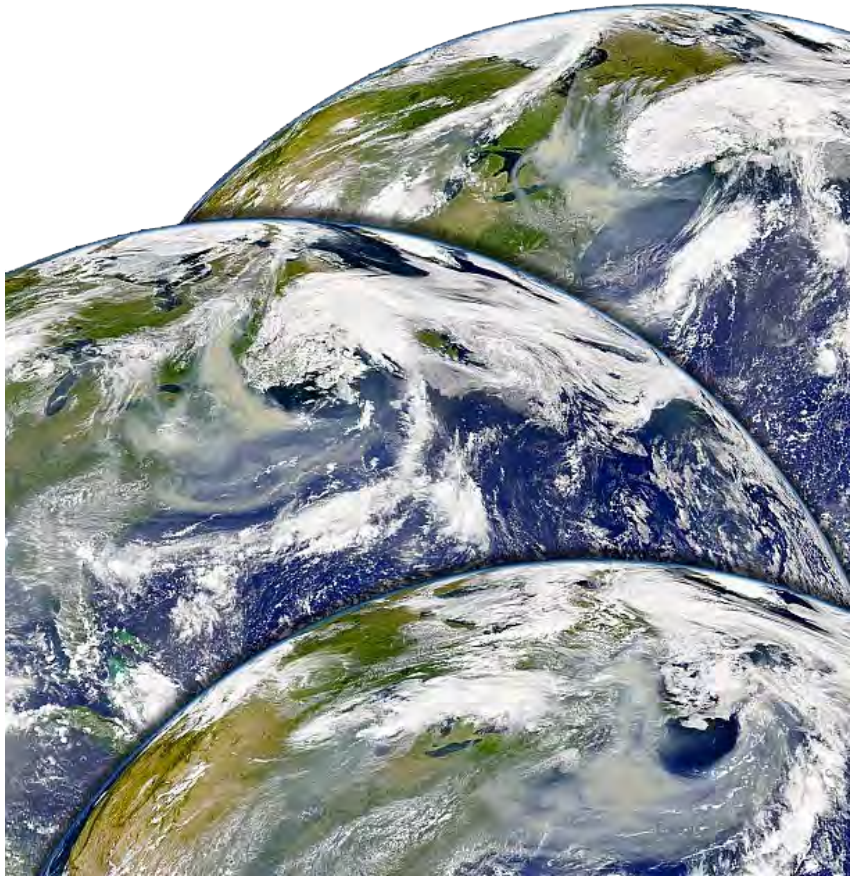


GEOS-5 Aerograms

National	International
Fresno	Select

- OC Organic Carbon Extinction
- BC Black Carbon Extinction
- ALL (OC + BC + SU) Extinction
- SS Sea Salt
- DU Dust
- SU Sulfate Extinction
- CO Concentration

International Cooperative for Aerosol Prediction (ICAP)

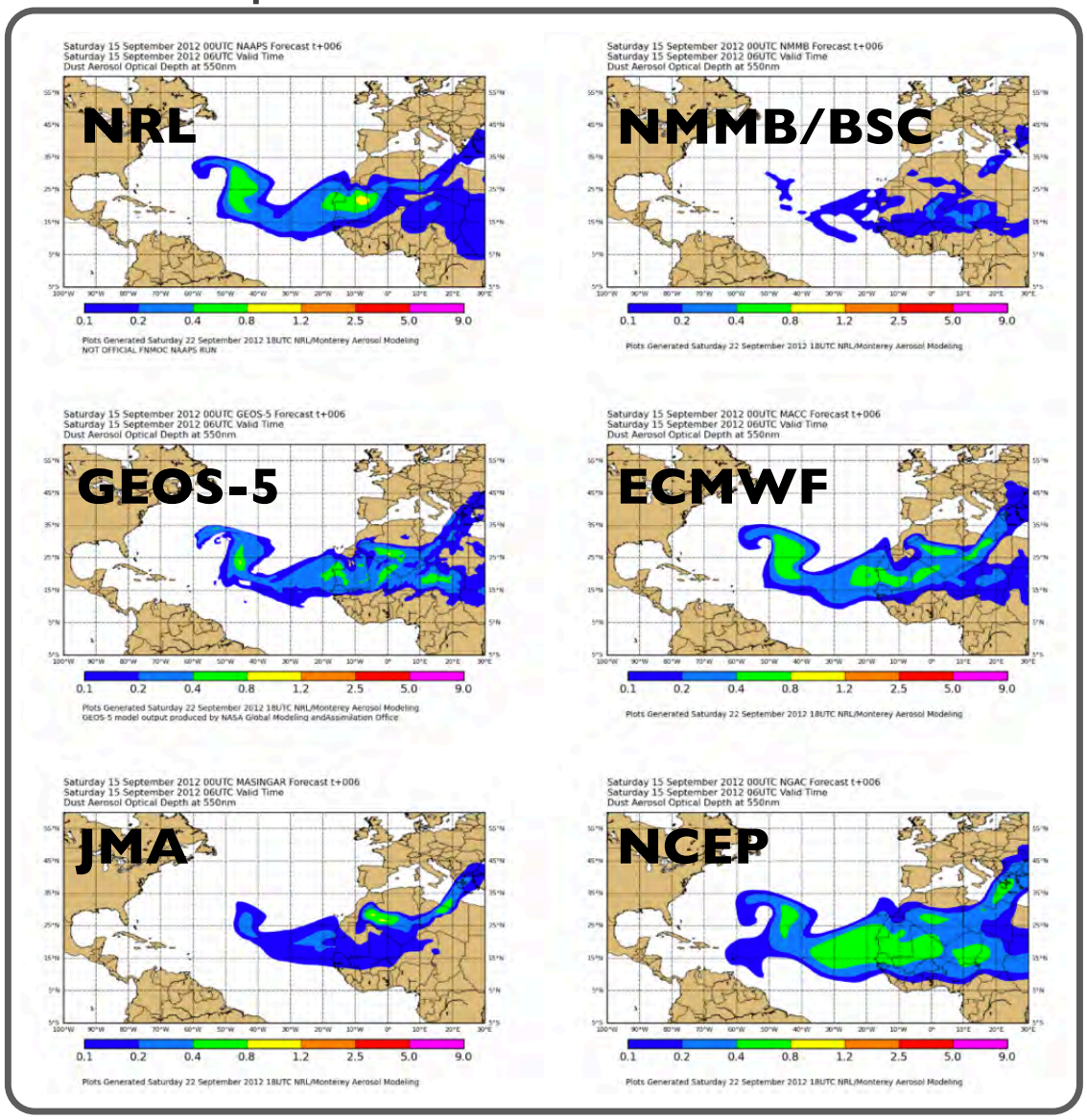


- ICAP is an emerging collaboration of "operational" aerosol forecasters and data providers to coordinate and improve aerosol prediction

- ICAP goals
  - Communication and collaboration between operational prediction centers
  - Communication and collaboration between model developers and data providers
  - Develop metrics for evaluating skill of model forecasts (similar to NWP community)
  - Develop techniques for aerosol data assimilation
  - Develop techniques for ensemble model forecasting Observability, Monterey, CA, April 2010

ICAP Accomplishments

- Participation from all major operational centers: NRL, NCEP, NASA, ECMWF, JMA, UKMO
- Participation from all major data providers: ESA, EUMETSAT, JAXA, NASA, NESDIS
- ICAP workshops
  - Observability, Monterey, CA, April 2010
  - Verification, Oxford, UK, Sept. 2010
  - Ensembles, Boulder, CO, May 2011
  - Sources & Sinks, Frascati, IT, May 2012
- Two workshop write-ups in BAMS
- ICAP Multi-Model Ensemble



ICAP Multi-Model Ensemble Dust Forecast

Summary

- SEAC4RS-NA will have a good mix of regional and global models
  - Diversity of emissions
  - Diversity of chemistry/physics
- Much of the forecasting infrastructure that was developed for SEAC4RS-Asia can be re-purposed for SEAC4RS-NA
  - Adapted for the revised science goals/*score-cards*
- We should leverage the concurrent DISCOVER-AQ/HS3 forecasting activities.
- Need to characterize model skill before deployment

Extra Slides

Useful GEOS-5 URLs, etc

Sample GEOS-5 Aerosol Data Products

2D Datasets

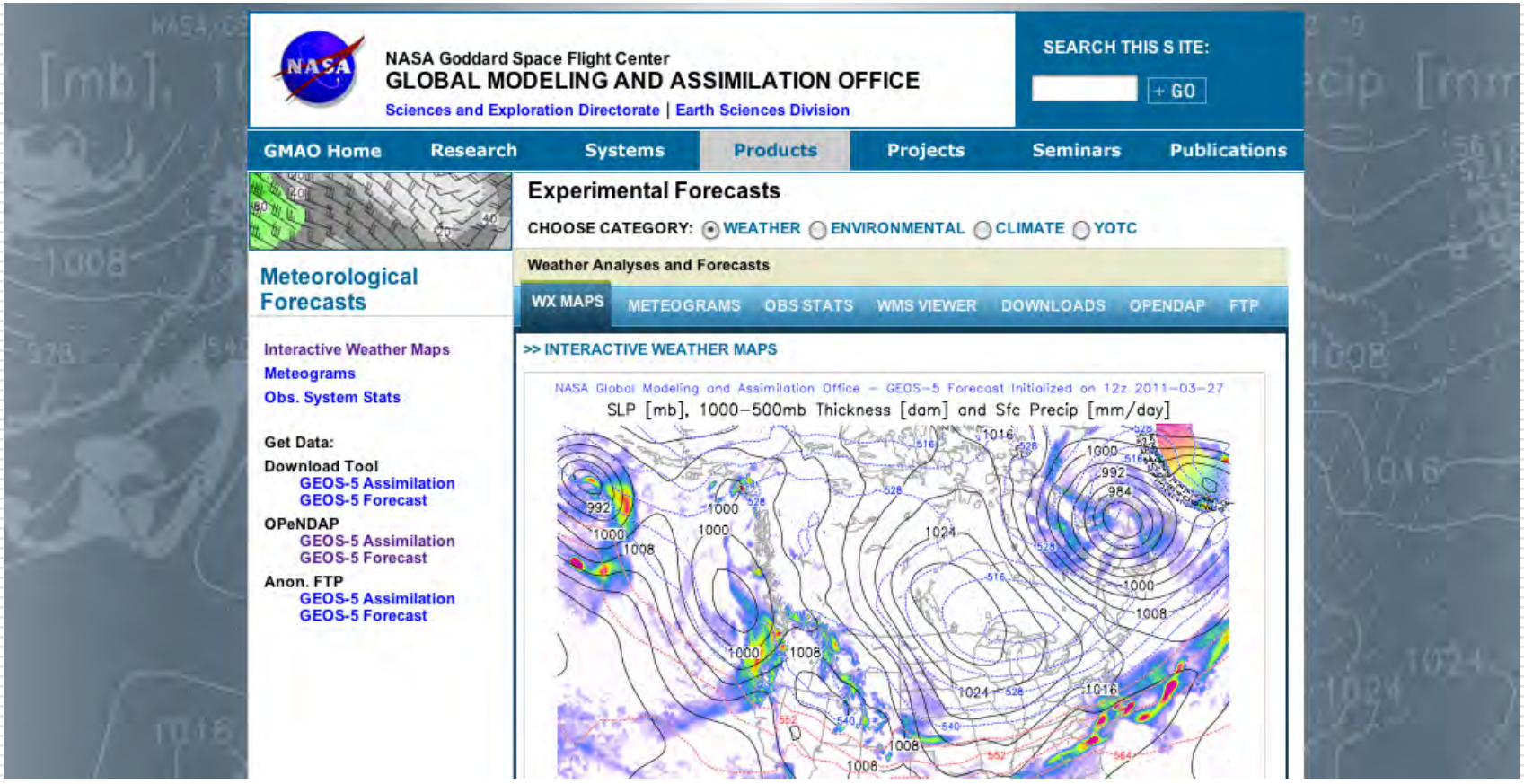
- Hourly, 3-hourly
- Speciated
  - AOT, AAOT, PM2.5, PM10
    - 12 wavelengths
    - 340, 380, 440, 470, 500, 550, 670, 865, 1024, 1240, 1640, 2130
  - Surface & column mass
  - Sources & sinks
- Non-speciated
  - Aerosol radiative forcing
  - UV aerosol Index

3D Datasets

- 3-hourly
- Speciated:
  - Aerosol mixing ratio
- Non-speciated
  - 355nm, 532nm, 1024nm
  - Aerosol Extinction
  - Single Scattering Albedo
  - Asymmetry parameter
  - Backscatter
  - Attenuated Backscatter (TOA & SFC)

In addition to Meteorological Products

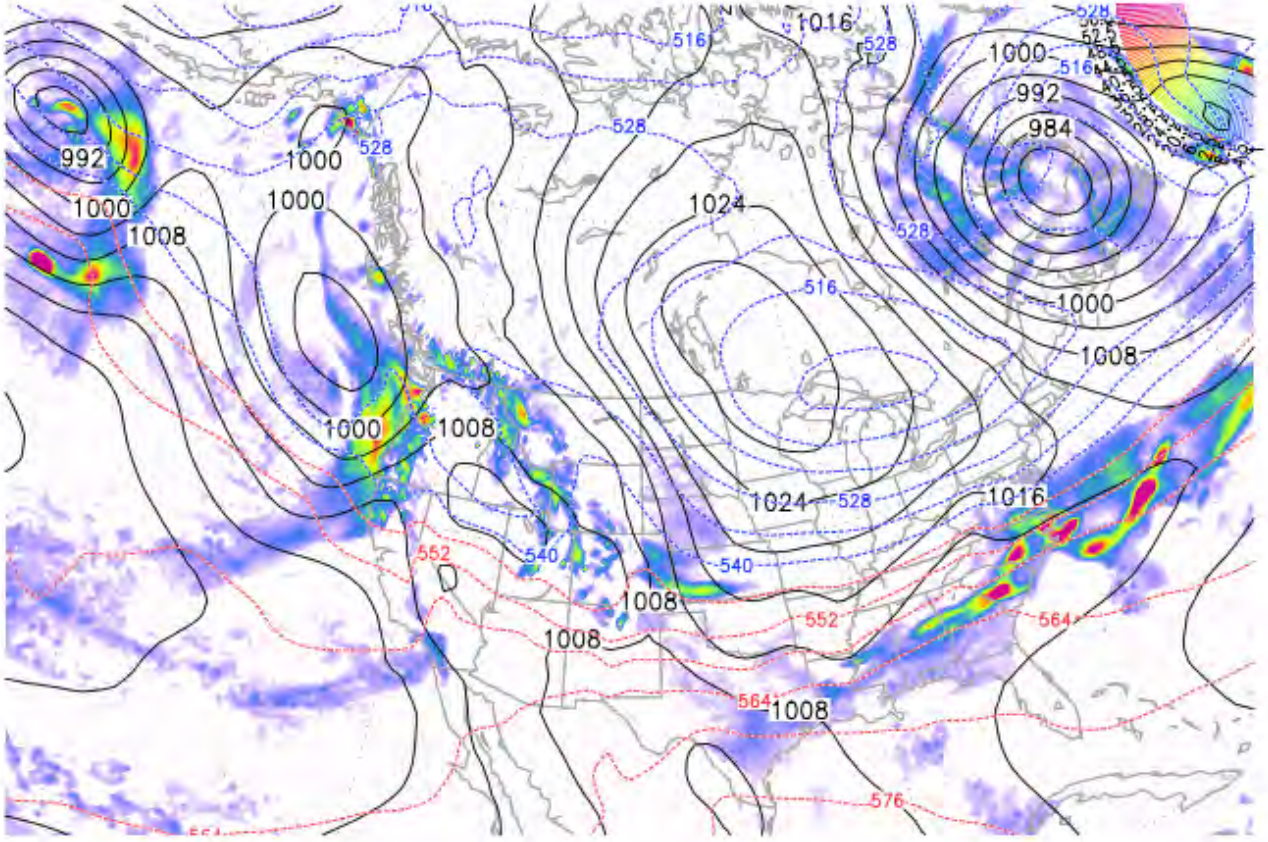
GEOS-5 NRT Forecasting - Meteorology



http://gmao.gsfc.nasa.gov/forecasts

NASA Global Modeling and Assimilation Office – GEOS-5 Forecast Initialized on 12z 2011-03-27

SLP [mb], 1000-500mb Thickness [dam] and Sfc Precip [mm/day]



0 hr forecast valid Sun 12z 2011-03-27

GMAO Experimental Forecast Suite

Site Developers: *Arlindo da Silva / Tommy Owens / Joon Yoon / Austin Conaty, GSFC 610.1*
Responsible NASA Official: *Michele Rienecker, GSFC 610.1*
Privacy Policy and Security Notice
Site Updated: *2009-06-09*

GMAO WxMaps

Forecast Initial Time

2011-Mar-27 12z

Forecast Lead Hour

000

Models	Variables
GEOS-5	300 Speed
GFS	500 Vort
	700 RH
	850 Stream
	Precip & SLP

Animate

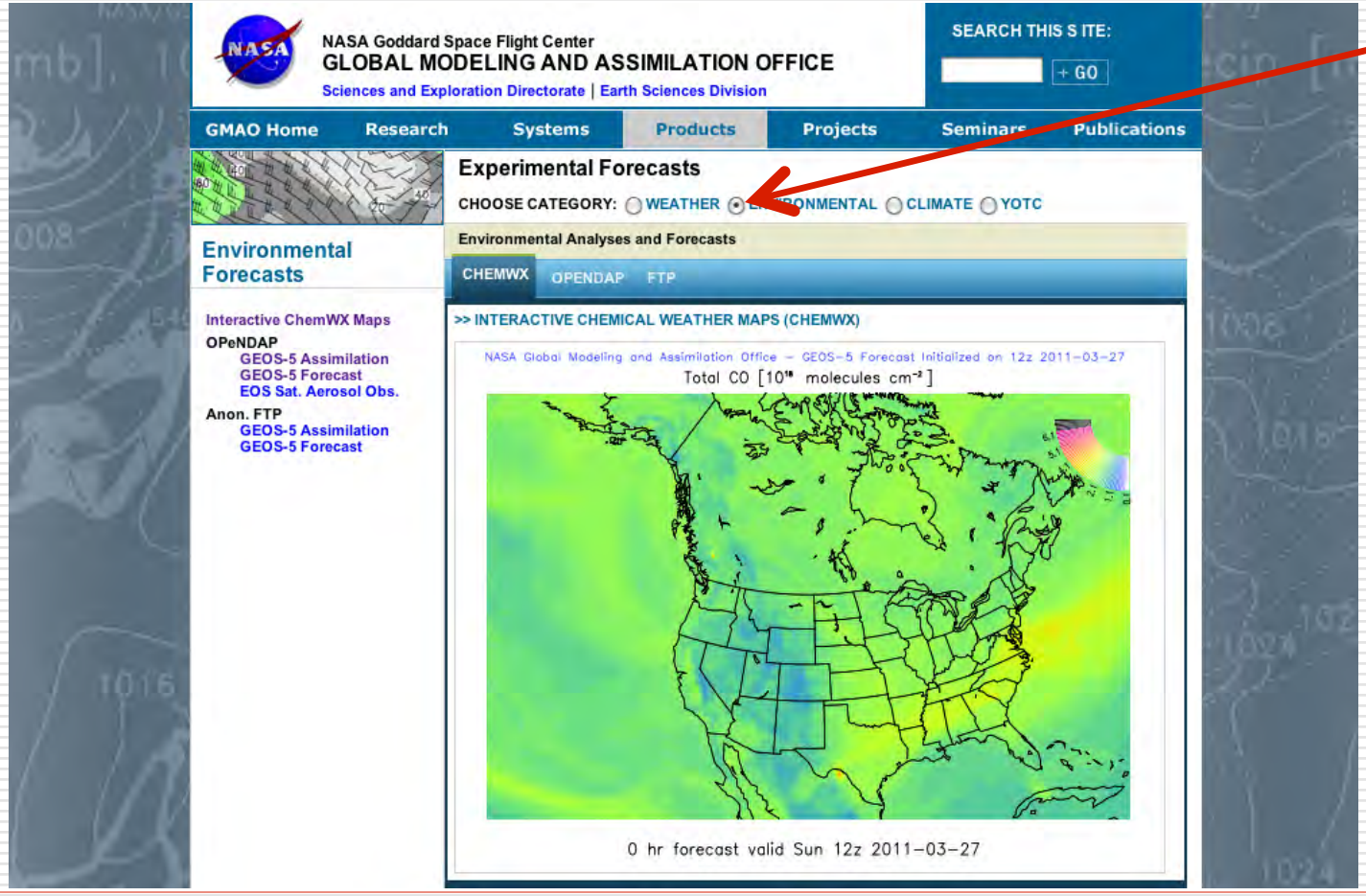
All τ for Precip & SLP
All Products for τ=0

Map Regions

Australia
Europe
Pacific
West Africa
Tropical Atlantic
North America

http://portal.nccs.nasa.gov/cgi-yotc/e561_fp_wx.cgi

GEOS-5 Forecasting - Aerosol & Tracers

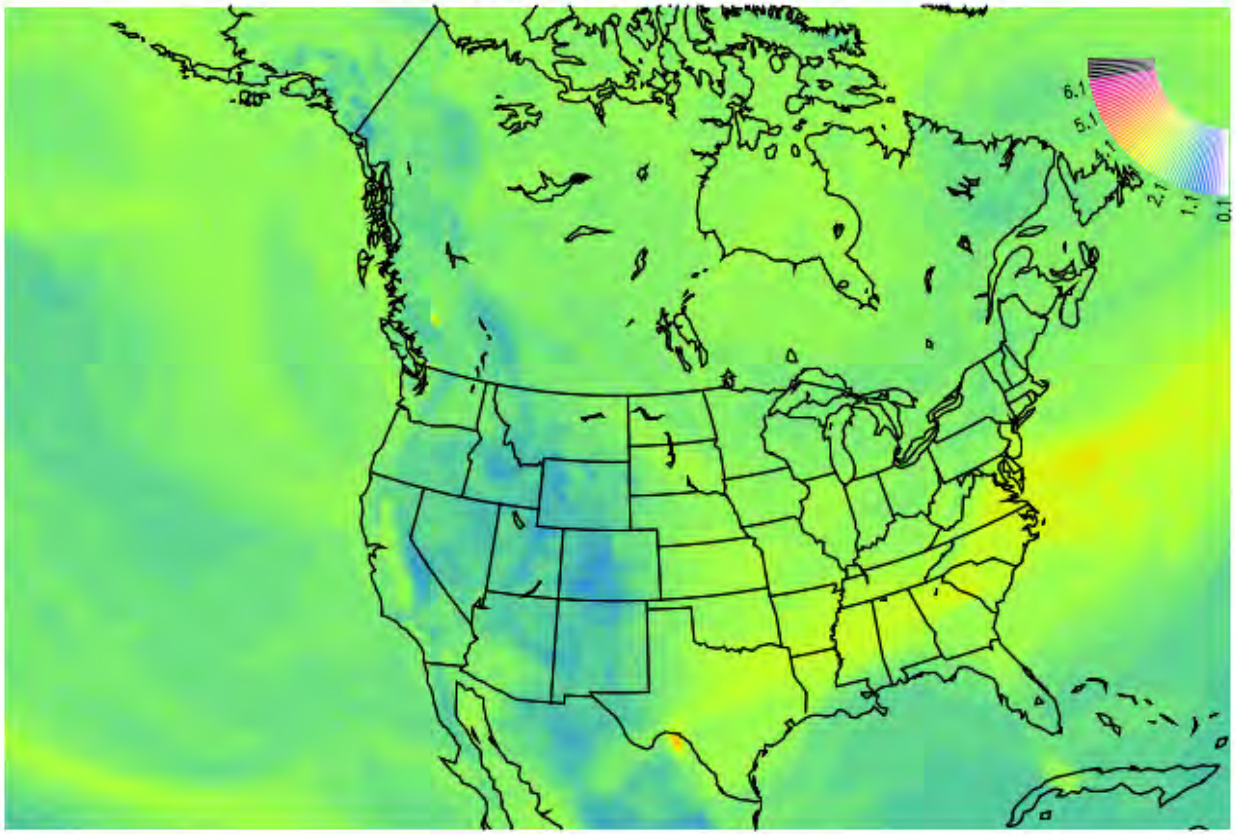


click

http://gmao.gsfc.nasa.gov/forecasts

NASA Global Modeling and Assimilation Office – GEOS-5 Forecast Initialized on 12z 2011-03-27

Total CO [10^{18} molecules cm^{-2}]



0 hr forecast valid Sun 12z 2011-03-27

GMAO Experimental Forecast Suite

Site Developers: *Arlindo da Silva / Tommy Owens / Joon Yoon / Austin Conaty, GSFC 610.1*
Responsible NASA Official: *Michele Rienecker, GSFC 610.1*
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Site Updated: *2010-06-28*

Map Regions

Fire Region 1
Fire Region 2
Global
nps
Pacific
North America

GMAO 2D ChemMaps

Forecast Initial Time

2011-Mar-27 12z

Forecast Lead Hour

000

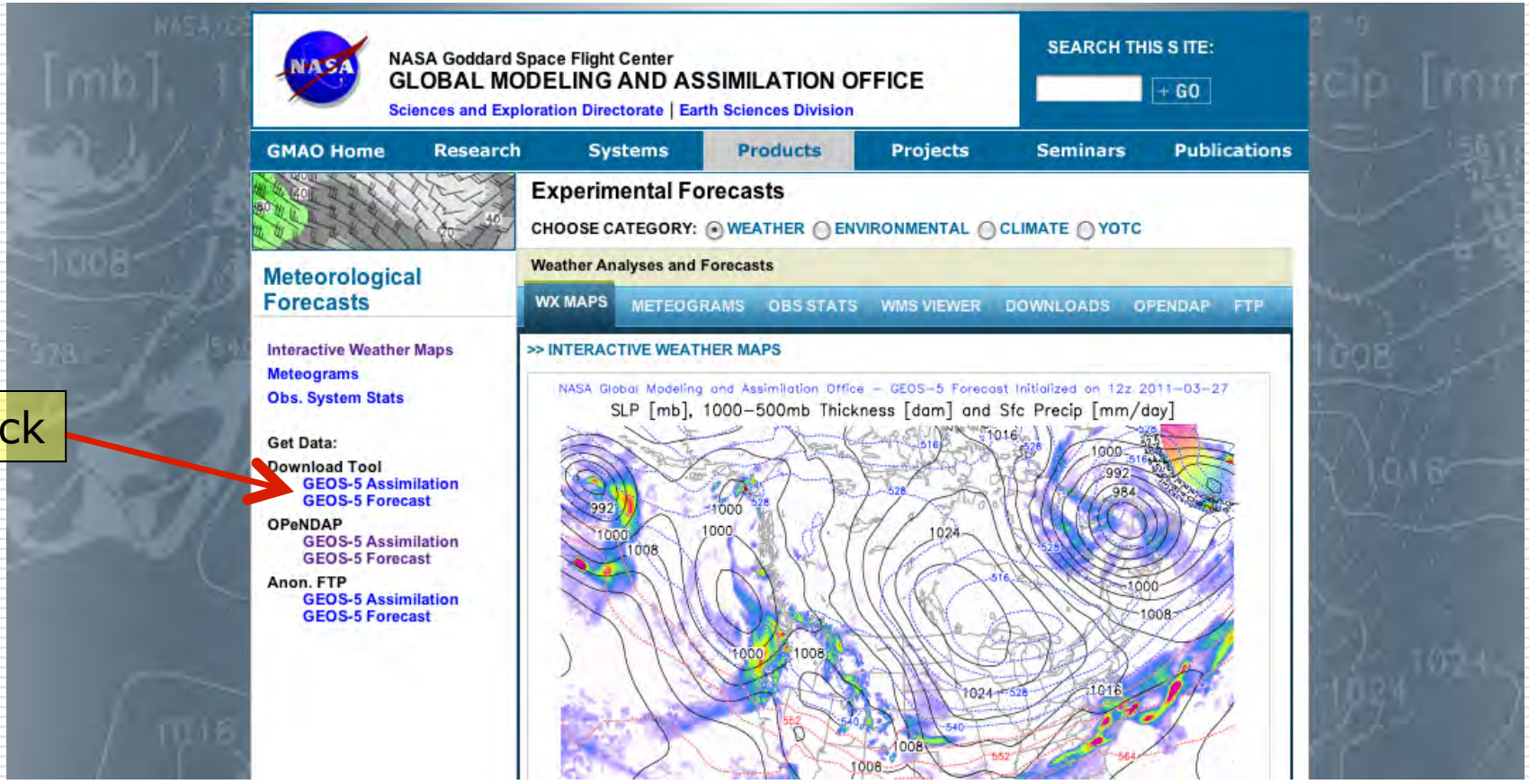
Models	Variables
GEOS-5	CO Column
	CO Biomass Burning Eurasia
	CO Biomass Burning Africa
	CO Biomass Burning South America
	CO Biomass Burning Other Regions
	CO Fossil Fuel Asia
	CO Fossil Fuel Europe
	CO Fossil Fuel N. Amer.
	Dust AOT
	Fine AOT
	Total AOT
	SO2 Column Mass
	SO2 Surface Mass
	Total Ozone

Animate

All τ for CO Column
All Products for τ=0

http://portal.nccs.nasa.gov/cgi-yotc/e540_fp_2d_chem.cgi

Getting GEOS-5 Data in NRT



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Getting GEOS-5 Data in NRT

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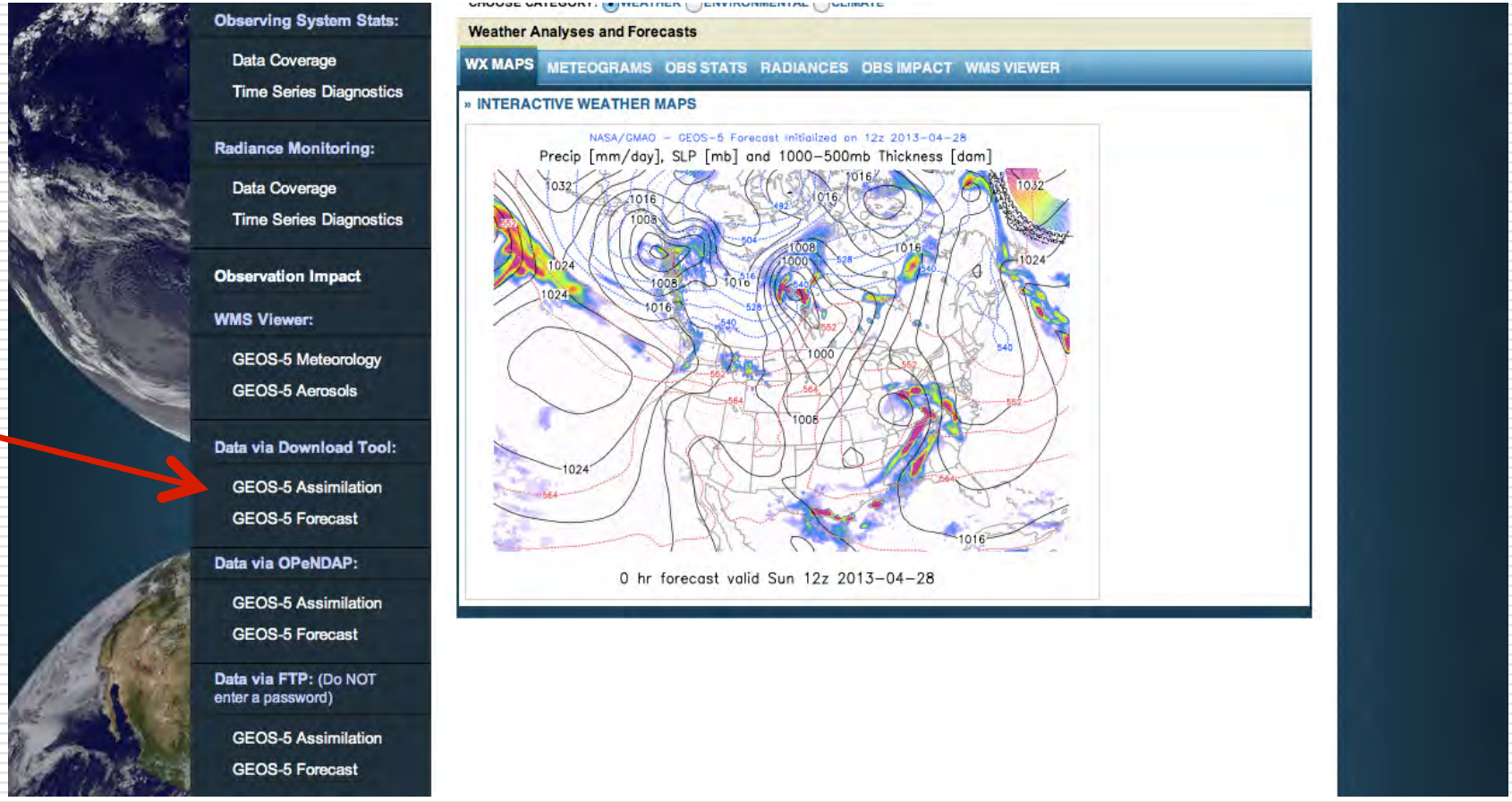

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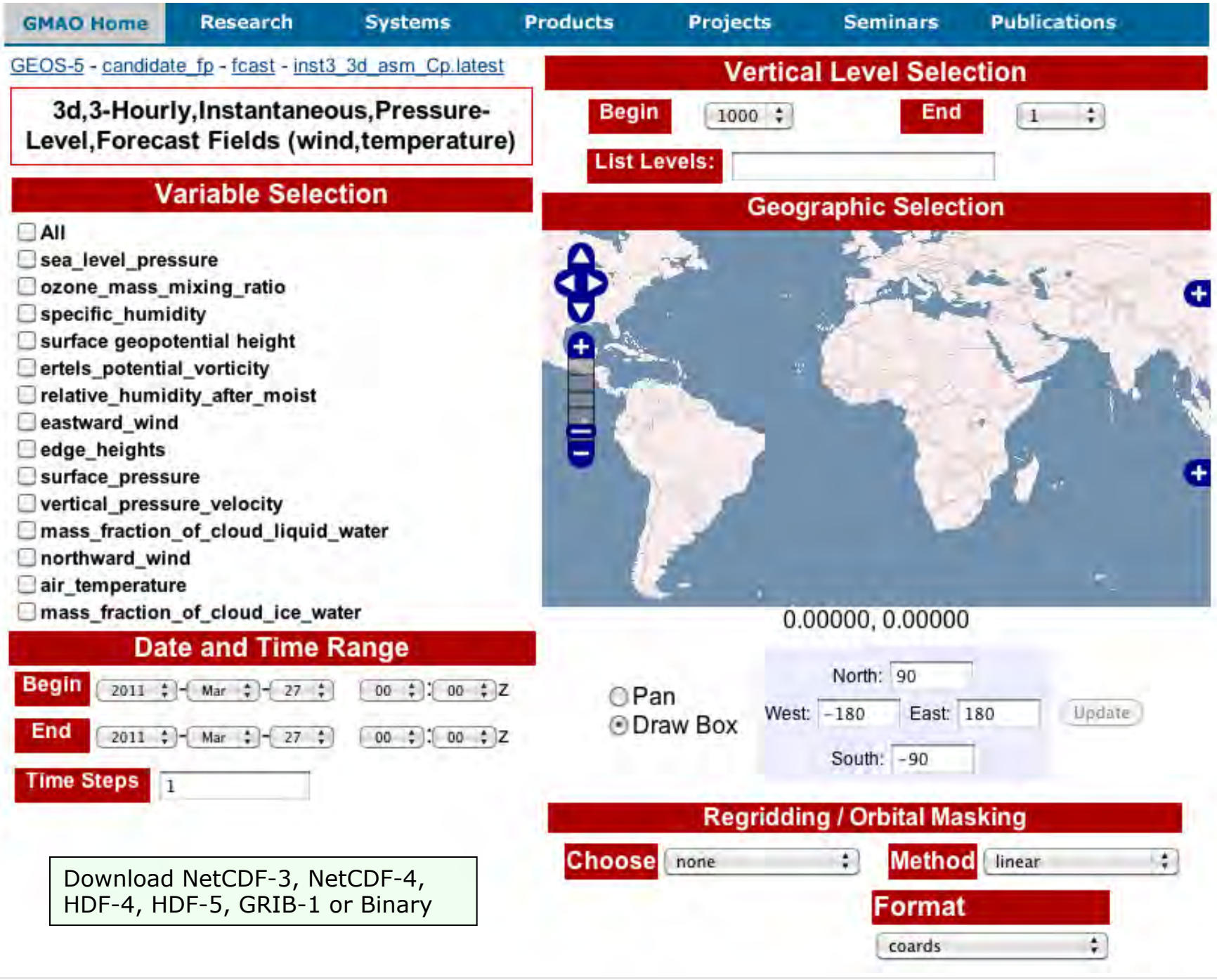
GMAO Home
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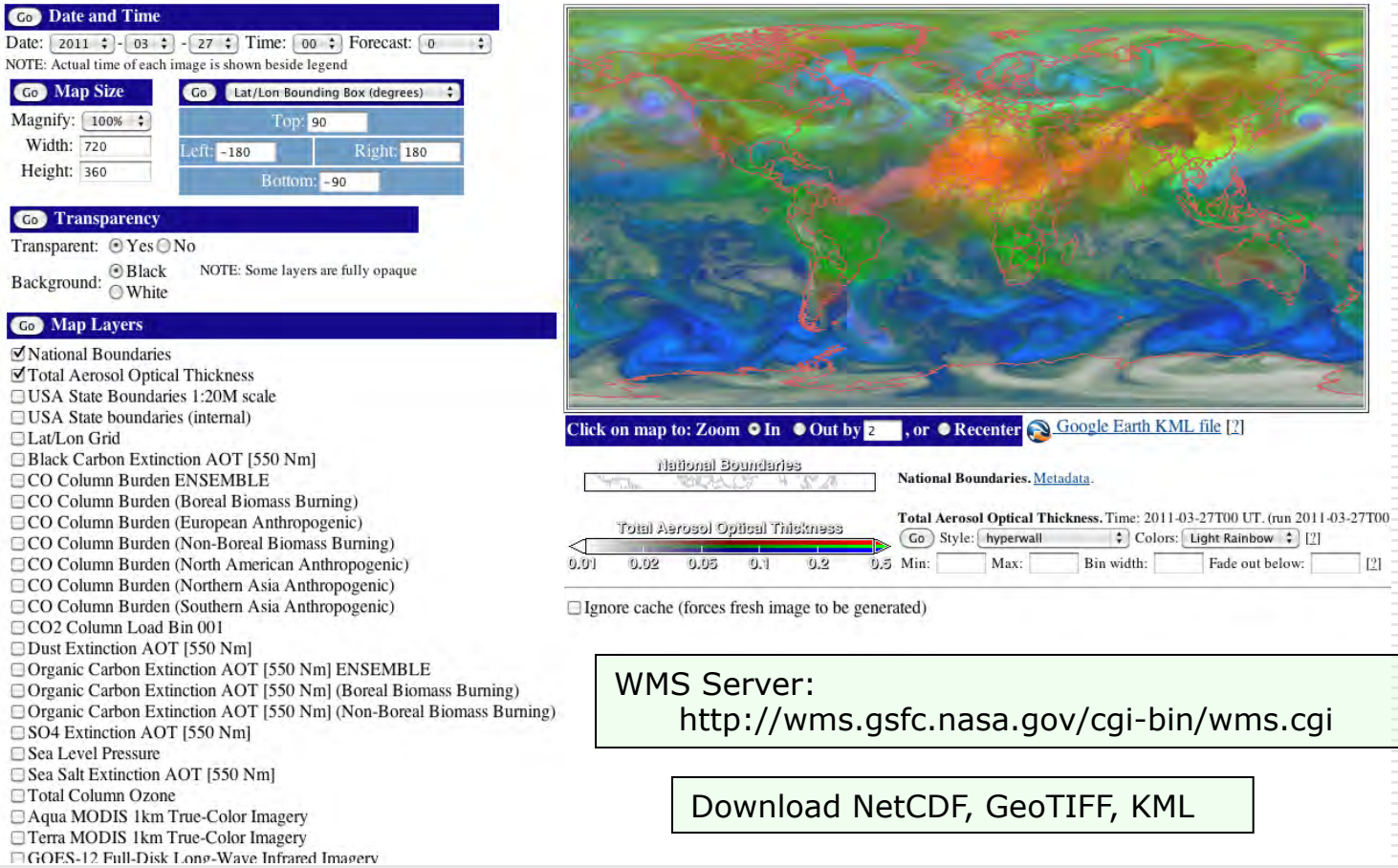
GEOS-5 - candidate_fp - fcast - inst3_3d_asm_Cp.latest
3d,3-Hourly,Instantaneous,Pressure-Level,Forecast Fields (wind,temperature)
Variable Selection
All
sea_level_pressure
ozone_mass_mixing_ratio
specific_humidity
surface geopotential height
ertels_potential_vorticity
relative_humidity_after_moist
eastward_wind
edge_heights
surface_pressure
vertical_pressure_velocity
mass_fraction_of_cloud_liquid_water
northward_wind
air_temperature
mass_fraction_of_cloud_ice_water
Date and Time Range
Begin
2011 - Mar - 27 00 : 00 Z
End
2011 - Mar - 27 00 : 00 Z
Time Steps
1
Vertical Level Selection
Begin
1000
End
1
List Levels:
Geographic Selection
0.00000, 0.00000
Pan
Draw Box
North: 90
West: -180
East: 180
South: -90
Update
Regridding / Orbital Masking
Choose
none
Method
linear
Format
coards
Download NetCDF-3, NetCDF-4, HDF-4, HDF-5, GRIB-1 or Binary

GEOS-5 WMS Server



WMS Server:
http://wms.gsfc.nasa.gov/cgi-bin/wms.cgi

Download NetCDF, GeoTIFF, KML

WMS Viewer: http://http://www.map.nasa.gov/cgi-bin/viewer.cgi?project=geos5-inst2d_hwl_x